THE TEACHER'S MANUAL

OF

OBJECT-LESSONS

AND

ELEMENTARY SCIENCE

BY

H. MAJOR, B.A., B.Sc.
Inspector of Board Schools, Leicester

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PREFACE.

The "Teacher's Manual of Lessons in Elementary Science" strictly follows the plan and method of its companion volume in Domestic Economy, which has recently met with so cordial a reception from educational authorities at home and abroad, the press, and teachers in all classes of schools.

The subject of Elementary Science, as some of H.M. Inspectors predicate, is destined to become a most important factor in education. To meet the want which has necessarily arisen the following Manual has been written, in which each section of a school, according to its special needs, is provided with subject-matter and method. It is evident that items, experiments, and illustrations which may be suitable to one standard, may be ill adapted or less adapted to satisfy children of a different age. The "Teacher's Manual" has, therefore, been divided into "standards", as in the volume on Domestic Economy.

Of course, the treatise is *suggestive* rather than exhaustive, and it is hoped that the "Notes" and "Methods" here given, if properly used as guide-posts and suggestions, will encourage rather than weaken initiative, and prompt to further invention in devising simple experiments, and thus strengthen individuality on the part of the young teacher.

To meet the requirements of different localities, and the varying aptitudes of different teachers, more material is provided than is necessary for any single school. But the head-teacher is the proper person to decide on the selection. Accordingly the Manual provides for alternative courses in Botany (Plants) and Zoology (Animals), whilst for those teachers who have no preference for life-subjects a course on "Earth-knowledge" has been provided in the lessons on Natural Phenomena of the Earth, Air, and Sea.

A very considerable proportion of the lessons in the Manual have been put to practical use and test during the last three years in a large group of schools. It is earnestly hoped that the success gained therein may lead to still further success elsewhere.

H. MAJOR

October, 1894.

The opportunity afforded by the rapid call for a second edition has been taken to carry out corrections of one or two trifling errors that were discovered.

June, 1895.

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ELEMENTARY SCIENCE.

PART I.

STANDARD I.

Government Requirements.—"*Any of the following alternative courses may be chosen in schools in which the same subject is not taken up as a specific subject. The courses should be taught throughout the school by means of conversational object-lessons in the lower standards, and more systematic instruction with the aid of text-books in the higher standards.*

"*The object-lessons given in Standards I. and II. should include in Mechanics and Physics some lessons on the phenomena of Nature and of common life. Specimens of a few such topics are given.*

"*If two standards are grouped together, the portion given to the lower standard may be taken one year, and that assigned to the higher standard, in the next year, in cases where this is practicable and consistent with the relation between the two portions; or the two portions may be taken in outline one year, and more fully in the next year.*

"*It is intended that the instruction in Elementary Science*" (*in which Mechanics and Physics are included*) "*shall be given mainly by experiment and illustration. If these subjects are taught by definition and verbal description, instead of by making the children exercise their own powers of observation, they will be worthless as means of education. The examination by the inspectors will be directed so as to elicit from the scholars as far as possible in their own language, the ideas they have formed of what they have seen.*"

"**Course I.**—*Lessons in common things in reference to the care of health and the conduct of life.*

Standards I., II. Thirty object-lessons on the chief tribes of animals, and their habits, and on common plants and their growth.

"**Course III.—Elementary Science.** *Schedule II. Class subjects. Art.* 101 (*e*).

Standard I. Thirty lessons on common objects, e.g., a postage stamp, the post, money, a lead pencil, a railway train. Food and clothing materials, as bread, milk, cotton, wool. Minerals, natural phenomena, as gold, coal, the day, the year."

Supplement to Schedule II. Alternative courses. Elementary Science.

INTRODUCTION.

In the following lessons in Elementary Science in Standard I., it will be noted, that all the subjects suggested by the Government as suitable to be taken, are included in the course; that these have been supplemented by other subjects kindred to them, or in close connexion with them, or still further illustrative of them; and that all these have been arranged in the order of difficulty. It will also be seen that these subjects have been treated inductively, and as far as possible experimentally; so as to appeal to the observation of the children, and to lead them up to inferences, and to verify these by further observation.

The author believes that this is the best method of garnering up material for future "reproductive and constructive imagination" (memory), on the part of the children. It is, perhaps, also the best mode of attack for making the study of the phenomena of nature a fit educative instrument for training the reasoning, as well as the observing, faculties of the child; and for teaching him "expression".

Of course, the class teacher will not attempt to give to the class in one lesson, all the items set down for one subject. On the other hand, the presentation as a whole of all the heads of the subject, is the most symmetrical mode of dealing with it. Frequently one head alone will suffice for a lesson in the actual giving of it before the class.

In those few instances where the class teacher may be presumably benefited by a knowledge of the subject a little wider than that given to the child, notes of "Special Information for the Teacher" are first given. These are not much required in this early stage, where the items are mostly concrete and well known; but they will become increasingly necessary as we advance to the upper standards.

One of the most important and valuable suggestions that can be given to the class teacher dealing with these items, is the urgent recommendation to consider everything that can be done and

shown to the class, in the high and dignified function of an experiment. It does not matter how simple the operation may be; if it yields some definite result, and leads to some inference, it fulfils the function of the most difficult and complicated experiment. Its very simplicity and freedom from disturbing environment, make it, for teaching purposes to young children, all the more instructive and educative, and therefore all the more valuable.

The help of the children should be enlisted to forage for the specimens required in this course; and the more natural these are, and the less like those prepared by school publishers, the more effective they will be for their purpose. Of course, they should be kept in the cupboard or school museum when not in use: and, still more of course, they should be brought out of the cupboard and used, not merely talked about, during the lessons. There is no greater temptation from which young elementary school teachers suffer, and to which they yield more frequently, than that of neglecting the latter item in the preceding sentence.

The "Notes of Lessons" are not intended, of course, to be used at the actual giving of the lessons. They are for previous study. Neither are they meant to be slavishly followed by the class teacher, to the weakening of individual initiative. They are rather suggestive: and especially so in the "Method" columns.

It is important that the teacher should be able to regard the Elementary Science Subjects from the Government point of view; and therefore we append here a few extracts from the revised instructions to H.M.I.'s on this matter.

"*Those managers and teachers who desire to continue the object-lessons of the infant school in due order through all the lower standards, and so to lead up to the regular study of Natural History or Physics in the higher, will probably think it better to treat Science as a class subject than to postpone specific instruction until the Fifth Standard.*

"*Accordingly, alternative courses in Elementary Science have been prepared, and are now appended to the Second Schedule of the Code. It is intended that, though varied in form, the several courses shall be substantially alike in difficulty and in educational value. . . . . Generally it may be said, that in estimating the results of instruction in the various class subjects, you should endeavour to keep in view a tolerably uniform standard of effort, accuracy, intelligence, and practical usefulness. But, subject to this one consideration, my Lords wish to leave to managers and teachers entire freedom in regard both to the selection and arrangement of topics, and to the methods employed in their treatment and illustration.*

"The examination will continue to be oral; but if the managers desire, the oral examination may, as regards the Fifth and higher Standards, be supplemented on Science subjects by written papers. When classes are large you may divide them for examination, and, if the managers do not object, examine one half on one subject and the other on the other.

"Besides the general scheme of progressive lessons on Science given in Schedule II., the alternative courses on this subject have been drawn to suit special departments of physical and experimental science which are to be pursued throughout the school course. Whatever the subject selected, it is necessary that the scheme should be well graduated, that it should be suitable to the age of the scholars, that it should make the scholars acquainted not with words only, but with the facts and materials of the outer world, and that it should be well illustrated by models, by diagrams and pictures of sufficient size, and, when practicable, by specimens and experiments. In sanctioning any modification of the printed schemes, it will be necessary to have regard to the experience and qualifications of the teacher, and to any special opportunities afforded in the town or district for instruction by a skilled demonstrator, who visits several schools in succession, or who gives collective lessons at suitable centres.

"Amongst the instruments of instruction in Elementary Science, reading books have been found to be of great value. In Standards I. and II. it will not, however, be necessary for you to insist on the use of a reading book for this special purpose. The best reading books for higher standards are those which are descriptive and explanatory, are suitably illustrated, and contain a sufficient amount and variety of interesting matter. But it is not necessary that the lessons in the reading book should cover the whole area of the course of instruction adopted for a class subject. It is presumed that the teaching on such a subject will be mainly oral. The chief use of the reading book is to give greater definiteness to such oral teaching, to make thorough recapitulation easier and more effective, and to invest the subject with new interest."

1. THE POST OFFICE.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—The **Post Office** in this country is a department of the Government, and has a monopoly of the collection and delivery of **letters, post-cards, newspapers, books** (sent through the "Book-post"), **telegrams, money** (so far as transmitted through "Post Office Orders" and "Postal Orders"), **patterns** (transmitted through the "Pattern-post"), and **parcels** (within certain limits). In addition, it conducts "Post Office **Savings Bank**", "**Annuity**", "**Insurance**", and other business, at **home**, and **abroad**.

For these various operations it is subdivided into special departments, as the **Telegraph** Department, **Intelligence** Department, **Packet Service**, etc., etc.

The whole is under the charge of a **Postmaster-General**, a member of the Government, with a salary of £2,500 per annum, assisted by **Secretaries** and other officers.

The chief office is at **St. Martin's-le-Grand**, London.

The total **income** of the Post Office is close upon £6,000,000 yearly; but the expenses are much less than this—the nett profits going to the reduction of taxation.

The work is subdivided into, (1) **Inland**, dealing with business limited to the United Kingdom; and, (2) **Foreign and Colonial**, for similar services abroad, in conveyance of letters, newspapers, etc.

II. Special Departments.—(*a*) **Letters**. These are **inland**, and **foreign** (and colonial).

The **inland** rate of postage is 1d. for all closed letters not above 1 oz. in weight, with ½d. additional for every 2 ozs. after the first two, for any destination within the United Kingdom.

For **foreign** countries in those comprised within the list of the "**Postal Union**", the payments vary according to Classes A and B, the former being 2½d. per ½ oz., and the latter rather more, as being **non-colonial, more distant**, or more out of the **usual track** of commerce.

(*b*) **Newspapers, Books, Samples, and Patterns.** The charge for **inland** postage for **newspapers** is generally ½d. each.

The **Book** rate is generally ½d. for each 2 ozs. inland and abroad, and inland **sample** and **pattern** post much the same; inland **parcel** post 3d. for first lb. and 1½d. for every additional pound; foreign at much heavier rates, according to distance, etc.

There are limitations as to size and weight in both (*a*) and (*b*). Insurance, and compensation for loss, in the above may be had by payment for it.

Payments are effected by means of stamps for the above, and also for registration of letters, etc., and for telegrams.

(*c*) The Telegraph business is now a Government monopoly, the nation having paid for the wires, plant, goodwill, etc., of the former telegraph companies. The inland charge is a minimum one of 6d. for 12 words and ½d. per word after: and the foreign according to distance and number of words.

(*d*) The Monetary business of the Post Office consists in the receipt and payment of money through the postal order, post office order, annuity, savings banks, and insurance departments, each having special regulations.

III. Internal Arrangements.—Besides the chief office in London, there are provincial centres, where business in some, or all, of the following departments is transacted—money orders, savings banks, telegraph, and postal orders. In still smaller provincial sub-offices postal orders are issued, but not paid; and on railways, mails are taken up, and delivered, by apparatus attached to the railway post office.

A list of these, and of the London suburban post offices, is published in the "Official Guide".

IV. Business Transacted.—The following statement in round numbers (and in millions), of the business done in the year ending 1891, will show the character and amount of the work performed by the Post Office in the United Kingdom alone:—

Letters, - -	1700 millions.	Newspapers, - -	160 millions.
Books, - -	480 „	Post Cards, - -	230 „
Parcels, - - - - -	46 millions.		

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2. THE POST OFFICE.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—If I wish to send a message, or a letter, to any one in this town (or village), some one in the school would be good enough to take it for me. I should call the boy or girl who took the message, the "messenger". But if I wished to send the letter to London, or to a foreign country, what should I do

then? (The postman would take the letter.) Why should I not send one of the children in school as my own messenger then?

There would be two reasons:—

(*a*) No one in the school could go; no one would know the way, or could be spared from home.

(*b*) I could not afford to pay for any one to go for only my one letter, or message.

A long time ago, when any one wanted to send a message or letter, he was obliged to employ in this way some messenger of his own for this purpose. Think what an expense it would be if every one had to do so now; and what very few letters there would be sent then!

II. The Post.—But about two hundred years ago, the king took up this work of carrying letters from one part of our country to another. This was a good plan; since when one messenger was going from one part to another to take one letter, he might as well take all the letters that were to be sent, and thus make the expense to each less. To make this plan work well, he would have to take all the letters. It would not do to let somebody else collect some of the letters in a place, and carry them, as if he were the postman. In a town or village no one is therefore allowed to collect the letters, and take them to the places to which they are to go, except the postmen. So when we speak of the "post office", we mean the place where the letters are collected; and we mean by the "postmen", the men who look after these things.

III. The Carriers.—To do this great work, the Queen, standing for the country, pays the railway people and the owners of steamers for this work, and then charges a certain sum for each letter. Of course, the farther the letter has to be carried, and the fewer there are of them to go to one place, the more each has to pay, if it is out of the country. But there is only one charge of a penny for all letters to any place in England, Ireland, and Scotland; and only a charge of 2½d. to most other places abroad.

There are some places to which letters are sent, where the post office loses money by doing this work, because it costs more to carry the letters than the money paid for them brings back. But, then, there are other places where it costs less, and a profit is made; and so, taking one with another, the post office always gains something. But the profits thus gained come back to the country again; for we do not have to pay so much in taxes, because of these profits.

IV. The History of the Post Office.—We now charge only one price for letters of one ounce from any part of this country to another; this is what is called the inland post. If letters go out of the country, to France and to other places, we call this part of the work done, the foreign post.

About sixty years ago every letter cost, taking one with another, a little more than sixpence. But then a great man, who may be called the "Father of the Penny Post", drew up a better plan; and since that time there is but one charge of a penny, for every letter of not more than one ounce sent by the inland post. This low charge pays better than the higher one used to do, because there are so many more letters sent now. The number also becomes larger every year, for several reasons:—

(*a*) First, there is more trade carried on year by year; and so more letters have to be written about it.

(*b*) Next, there are more people to write every year.

(*c*) And lastly, as schools increase, there are more people who can write than there used to be.

At the present time there are 1,700 millions of letters sent every year; and this is about 20 for every man, woman, and child in the country.

V. Other Work.—But letters are not the only things carried by the post now: there are newspapers, books, and patterns sent too. And if we want to send money, we can pay our money to the post-master, and he will give us a post office order, or a postal order, which are promises to pay. The person who gets this printed piece of paper from the postman takes it to the post office, and has it changed for the money that had to be sent. Of course the sender has to pay a small sum for this; but, as it is only a penny (or sometimes only a halfpenny), for any sum less than ten shillings, it does not come to a great deal after all; and we are sure that our money will be safely sent.

If we sent money in a letter, instead of by post office or postal order, it might be stolen by the postman on the road; and so the post office gives orders that no money may be sent in this way. If we want to send very small sums, we can do so by means of stamps which we can change into money at any post office near us.

3. NOTES OF LESSONS—THE POST.

Apparatus.—1d. and ½d. stamps, and envelopes—plain, directed, and one which has been sent through post.

Matter.	Method.
I. Introduction— When we want to send news to, or receive news from, distant friends, we write *letters* to, or receive letters from, them. We drop the letter into a letter-box at the post office, or a pillar-box in the street.	I. Ask children where they take their *letters* to when they wish to send them away. (To the post office, or pillar-box.) Ask how we know a post office. (By name set up over shop, and by the letter-box in the window.)
II. What takes place at Post Office— The letter put into the letter-box falls into a basket or skip. This is "*cleared*", or emptied, at certain times; and the letters *arranged* with stamps and directions uppermost. The *stamp* is then marked with a number, and the *envelope* with the name of the town, by "*stampers*". The letters are then *sorted* into heaps, according to the places to be sent to, by "*sorters*". They are now tied up in bundles, and put into canvas bags. These are sealed with wax, which is also stamped. They are next taken in *vans* to the station. Here they are put into *mail trains* (*letter trains*), and sent to their different places. The mail bags are met at the other stations by porters, who take them to the post office, *stamp* on the date and number of town, and *sort* them for different districts; and they are at last "*delivered*", or carried to the houses by the postmen or letter-carriers in livery.	II. Explain what takes place in a post office. Why is the stamp marked at all? (So that it may not be used again.) Why are all the stamps placed *uppermost*? (So that the stampers may do their work more quickly.) Write different names of towns on bits of paper, and show how to sort these. Why are the letters tied up in bundles? (To keep them together, so that the work may not need doing twice.) Refer class to the large *van* painted red, which runs from the post office to the railway station to take and bring the letters. What kind of trains are "*mail trains*"? (Those that carry letters, newspapers, books, etc.) Explain that after reaching the towns the bags are taken to the post office, and the letters go through the same processes as at the *first* office. Ask children how they are delivered to their own houses. (By the district postman, who knows the streets and houses well in his own district or part of the town or country.)
III. Deliveries— In *towns* there are several deliveries daily, according to the number of letters sent to be delivered. *Villages* only get one; *London* about nine. Some towns, as London, have no *Sunday* deliveries. This gives the letter carriers and others a *rest*.	III. Show that with only one delivery a day the work could not be done quickly in towns where there are very many letters to deliver. Compare the needs for collection and deliveries, and means of supplying them in this matter in villages with London. Ask for advantage of no Sunday delivery.

NOTES OF LESSONS—THE POST—*Continued.*

Matter.	Method.
IV. Branch Offices and Pillar-Boxes— These are for people at a distance from the central office. The letter-boxes have the times when "cleared" printed on them. A postman at these times unlocks the box, takes out the letters, and locks the box again, doing this at all the boxes in his round. He carries these letters in a bag to the "General" or large post office of the town or district.	IV. Why need we pillar-boxes? (To save people the trouble of taking their letters, etc., to the post office.) Notice the great benefits derived from branch offices, etc. (Stamps, orders, etc.) Why need the "clearance times" be printed on the boxes? (For people to know when to have their letters ready.) Tell class to notice the pillar-box nearest them, and wait for postman to see what he does at it.
V. Other Work of the Post Office— Besides the *letters* there are the sale of *stamps*, etc., the *telegraph*, *money orders*, *savings banks*, *pattern post*, and *parcel post*. These are all under the "head" of the post office, who is called the "Postmaster General", but who has many officers under him to assist.	V. Ask class what else can be obtained at post offices. Tell how telegraph work is done. Show a money order, and explain its use. Notice Savings Bank forms (stamps). Describe very briefly the work of the "Postmaster General". Show a telegraph form, and fill it in. Do the same with a P.O. and a P.O.O.

4. NOTES OF LESSONS—A POSTAGE STAMP.

Apparatus.—Stamps (stamp-album, if possible *), coins, a stamped envelope, book packet, and parcel for parcel post; also a receipted bill.

Matter.	Method.
I. General Description— (*a*) *Shape.* Stamps are of many *shapes.* Some are oblong, others square or round, and some even three-cornered. Ours are *oblong* in form, and compare with shape of a slate, copybook, etc. An oblong shape is one with four square corners, but with sides of different sizes.	I. (*a*) Show children stamps of different *shapes*, *colours*, etc., and ask for the names of these different shapes. From a collection of English stamps show that the *oblong* form is general with us. Draw on the blackboard a large copy of a stamp, and obtain in doing so the various items in "Matter" column.
(*b*) The *edges* are pierced in order that the stamps may be torn off easily. This is also done in some newspapers, account books, etc., where we have to separate the leaves without tearing them across.	(*b*) Show a sheet of stamps, and point out the way in which they are joined to each other so as to be easily separated. Show children how to do this roughly by *pricking paper* with a pin, but note that stamps are so done by *machines.*

* Imitation sheets of these are sold at 18 stamps for 1d.

NOTES OF LESSONS—A POSTAGE STAMP—*Continued.*

Matter	Method.
(*c*) *Face or front.*—The front of a stamp generally has the head of the *ruler* (king, queen, etc.) printed on it. (In England it is the Queen's head.) On the head is a *crown*; and in the space round the head are some words ("Postal and Inland Revenue") to show the uses of the stamps. At the bottom of the stamp is the *price*, or what it costs to buy it. (*d*) *Colours*, etc.—These are different according to the value of the stamp, so that the stamps may be easily known from each other. Some are red, others green, blue, yellow, violet, etc. When a stamp has been *used* once, it is of no more use. The stamp is marked with a number by the post office servants. The back of the stamp is covered with gum, as in some labels, so that it may stick to the letter or paper on which it is placed.	(*c*) Show several stamps, and draw one enlarged on blackboard. Ask whose *head* is on the stamp. (Queen's.) Show the class coins, and compare the "images" on them with those on stamps. What does the crown on the head show? (Ruler: Queen.) Why should the *price* be printed on them, and why of different *colours*? (For convenient handling in selling.) Show some *foreign* stamps. (*d*) Show ½d., 1d., 2d., 2½d. stamps, and note different colours. Show a *used* stamp, with its black lines and number across it, and explain that it could not now be again used without this being known. Tell children how this marking is done at the post office by "stampers", very quickly one after the other. Why covered with gum? (To save time and trouble.) Show this by gumming a piece of paper, and sticking it on another piece, that the children may see what a long time it takes to do this separately for each piece of paper.
II. Particular Description— At first stamps were not used, but *money* instead, to pay for sending *letters*, *newspapers*, etc. At first, also, it was only letters and newspapers that were thus sent. Now *books* and other things can be sent by the payment of stamps. Stamps are used in *other countries* to pay for the same carrying of letters, etc., as in England. So each country has its own stamps; and these will be of different colours, etc., for different prices, as in England.	II. Make the class understand how the postmen without stamps would have to wait at every door for the *money*. Show the class a *book*, and how it is done up to send away by "book post", and where the stamps are put, and how many are required for each quarter lb. Show the class a few *foreign* stamps. Let the children note their different *prices*, *colours*, and *shapes*; and the different heads of *rulers* there are printed on them.
III. Kinds of Stamps— The money we use daily is made of different values; so are stamps. We have ½d., 1d., 3d., 6d., etc., coins; and stamps of the same prices, and with these we can make up nearly any other small amount of money, and thus send letters of any price.	III. Which stamp is generally placed on the letters which come to your house? (1d. one.) What is its colour? (Lilac.) What stamp generally brings newspapers? (½d.) What is its colour? (Red.) Ask what stamps to use to make odd amounts such as 4½d., 7½d., 3½d., etc.

NOTES OF LESSONS—A POSTAGE STAMP—*Continued.*

Matter.	Method.
IV. Uses of Postage Stamps—	
(*a*) To pay for carriage of *letters* and *newspapers* by *letter post.* Somebody must be paid for doing this work.	IV. (*a*) Show that by buying stamps and placing them on *newspapers, letters,* etc., time and trouble are saved. Refer to letter-boxes at street corners in same direction.
(*b*) To pay for *carriage* of *parcels* by *parcel post.* These are carried by the post office people, like letters and newspapers.	(*b*) We weigh a *parcel*, take it to post office, put on the stamp, and all our labour is then done, and the parcel is next delivered safely to our friends.
(*c*) To send instead of small sums of *money*, and to make up larger sums.	(*c*) If we owe a friend 1s. 6d. how, not in *money*, can we send it? (By sending 18 penny stamps.)
(*d*) For *saving up money* instead of coins for the *post office savings bank.*	(*d*) Show a stamp sheet used in collecting pence to make up to 1s. for the *post office savings bank.*
(*e*) For *bills* of over £2 which are obliged to have a 1d. stamp put on them when they are paid.	(*e*) Show on the blackboard how to "*receipt*" an imaginary bill of over £2.

MEANS OF LOCOMOTION.

5. RAILWAYS.

SPECIAL INFORMATION FOR THE TEACHER.

I. History of Railways.—Railways owe their origin to the less friction between rails and wheels, than between wheels and a road, however smooth the latter may be. The first railway used planks instead of rails; and was established near Newcastle-on-Tyne for the transport of coal from the mines to the place of shipment. In this instance, horse power was used for traction; as on roads elsewhere.

Later, the steam locomotive replaced animal power. The present great railway system of England was inaugurated by the opening of the line between Liverpool and Manchester in 1830, succeeded by the London and Birmingham line, etc., until now all large towns are connected with each other, and with London, by railways.

At first the lines were single, then double; now there are on

the great trunk railways separate double lines for **goods** and **passengers**. At first, also, the rails were made of **iron**; now they are increasingly made of **steel**. Recently the **telegraph** has been connected with the working of railways.

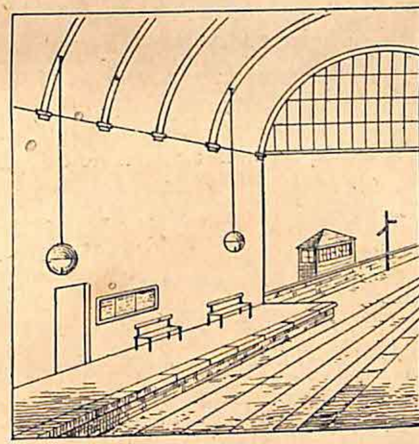
II. What a Railway is.—A railway essentially consists of a double line of **rails**, **equi-distant** from each other, made of iron or steel, resting on **sleepers**, to which they are affixed by **chairs**.

At the present time there is practically only one **gauge** (or width between the rails) in all England, so that trains may pass from any one system to any other. This is the **narrow** gauge of 4 ft. $8\frac{1}{2}$ in.

The line of **route** taken is as **straight** as can be, after providing for:

(1) The passing through, or close to, **towns** which will feed the traffic.

(2) Avoiding difficult **obstacles**, such as **mountains**, **valleys**, wide parts of **rivers**, etc. These difficulties, where they cannot be avoided, are overcome by **cuttings**, **tunnels**, **inclines (or gradients)**, **embankments**, and **bridges**; all of which, however, add materially to the average cost of construction per mile. The **gradients** are generally so chosen that the material removed out of the cuttings and tunnels, shall as far as possible suffice to make the necessary neighbouring embankments; and so that the accelerated velocity acquired going down a gradient may help to carry the train up the next incline.



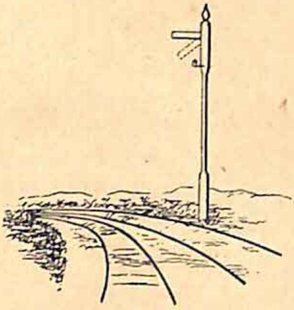
Railway Station.

Stations are provided wherever **goods** and **passengers** have to be taken up and set down; and, besides, there is a **terminus** at each end of a trunk line. At the termini there are large **goods** stations and warehouses for the collecting and storage of goods traffic.

There are also **sidings**, especially on single lines, for the tem-

porary withdrawal of one train to let another (an express, etc.) go by.

The "**block system**" of telegraphing is now largely adopted on all the larger railway systems, and prevents a train entering on a given section until the line is "clear" from any other train, so as to reduce the risk of collisions. This blocking is worked through **signal boxes**.



Railway Signal.

Among the largest railway **engineering** triumphs are the following in Great Britain :—

The Forth Bridge and the Tay Bridge across two arms of the sea; the Severn Tunnel and the Mersey Tunnel underneath two estuaries.

III. Administration.—In England the railways are not State property, but belong to **railway companies**, who regulate the traffic through **directors**, subject to the approval of the **Board of Trade**, which supervises the **Bye-Laws**, and whose consent as to tolls and other charges must be obtained.

IV. Business Done.—A few figures, merely in round millions, will show the amount of work performed by the railway systems of this country.

Total **mileage** about 20,000 miles (one half of it in double lines).

Total expenses of **construction** about £900 millions (increasing yearly).

Total annual **revenue**,	- -	about	£90	millions.
" " "	**for passengers**,	"	£34	"
" " "	for **goods**,	"	£43	"
" "	**expenses**, - -	"	£43	"
" "	**nett revenue**, - -	"	£36	"

Total number of persons **killed** on railways annually about 1,000.

Total number of persons **injured** on railways annually about 5,000.

Of the latter two items, most consist of railway servants.

V. Principal Lines.—These are those between London and the large towns, and specially—

(1) **The Great Western (G.W.)** with 2,500 miles open (nearly).

(2) **The London and North Western (L.N.W.)** with 2,000 miles open (nearly).

(3) **The Great Northern and North Eastern (G.N. and N.E.)** with 1,500 miles open (nearly).

(4) The Midland (M.R.) with 1,300 miles open (nearly).
(5) The Great Eastern (G.E.) with 1,200 miles open (nearly).
(6) The North British (N.B.) with 1,000 miles open (nearly).

6. NOTES OF LESSONS—A RAILWAY TRAIN.

Apparatus.—Pictures of train, tender, carriages, and engine; and (if possible) a toy model of this.

Matter.	Method.
I. Kinds of Trains— (*a*) *Passenger* trains, to carry people. These run at a great speed (30, 40, and up to 60 miles an hour). They also carry light goods, such as newspapers, parcels for parcel post, and small parcels for trade. (*b*) *Goods* trains. These carry coal, timber, iron, flour, etc. These are all *heavy* goods, and those not needing *speedy* transport.	I. (*a*) Ask class for different kinds of trains. Ask what the fastest *passenger* trains are called. ("*Express.*") Compare speeds with those of horse and ship. Get from the class why so many people are constantly moving about in trains. (*b*) Notice difference from (*a*) in *speed*, and *weight* carried. Get from class articles brought by goods train.
II. Description of Passenger Train— (*a*) *General description.* A passenger train is made up of an *engine* ("iron horse"), and "*tender*", *guard's* van, *luggage* vans, and *carriages* divided into compartments, and called 1st, 2nd, and 3rd class carriages. (*b*) *Particular description*— (1) The *engine and tender* are joined together. The former contains a *furnace*, where the coal burns: the latter carries the coal and water. (2) The *boiler* is the round part heated by the fire, where the water is turned into steam. (3) There are two chimneys; the larger one in front for the *smoke*; and a smaller one at the back for the *steam*. Sometimes the smoke and steam pass through the *same* chimney. (4) Between them is a steel dome, which also lets out steam.	II. (*a*) Deduce as many of these parts as possible. Why should the engine be called the "iron horse"? Get uses of the different vans, etc., from the class. Note that 2nd class carriages have been largely done away with, as they mostly did not pay. (*b*) (1) Show a picture or a toy model of engine and tender, and point out on it all the different parts mentioned. Refer to the very heavy weight of the coal and water in the tender. (2) Explain how the steam works the engine by reference to steam in a kettle lifting the lid. (3) Point out on the picture and model the *chimneys*, *dome*, and *boiler*; and note how large the latter is, and enquire the reason why. Ask what name we give the chimneys in a steam-engine and a steam-boat. (Funnels.) (4) Explain meaning of "*dome*" as a rounded ceiling, and why steam must be sometimes let out.

NOTES OF LESSONS—A RAILWAY TRAIN—*Continued.*

Matter.	Method.
(5) In front of the engine, on a framework, are two large "*buffers*", to break any shock when meeting carriages, etc. Compare different shock when an india-rubber ball and a glass marble are dropped from a height on a stone floor; in the latter instance the marble often breaks.	(5) Show the "*buffers*" and tell class how they act; illustrate by pushing a pencil against an india-rubber ball, to represent the elastic spring or recoil. Show that this elastic recoil makes travelling comfortable, when stopping at stations, etc.
(6) The *tender*, besides carrying the coal, carries the water, in a cistern; and has boxes for the engine driver and stoker to put their meals, etc., into.	(6) Ask what is carried on the tender. (Coal and water.) Note the differently sized wheels on the engine and tender. Point out these boxes in the picture.
(7) It takes two men to work the engine, a *driver* and a *stoker*. The latter makes the *fires*, turns the *brake* on or off, and attends to the *boiler*. The former sees to the *driving* parts.	(7) Get from the class the work of the driver, and tell how he turns on the steam to drive the wheels; and that he must have good *eye-sight*, to tell the colours on the signal posts at night
(8) The *guard* instructs the driver when to stop, go on, etc. He has a "*guard's van*" to himself. From the engine to the guard's van at the end of the train runs	(8) Tell the fittings of guard's van (letter-racks, brake, etc.); also what the guard's work is; and get from the class why he is called a "guard". (He *guards* or *keeps* the train from accidents.)
(9) The *signal cord*. If this is pulled, the driver stops the train. Sometimes, where there is not much trade, the guard's van is also used for luggage; or there is a separate van called	(9) Explain the use of this cord, in case of accident; and the need of the caution against its undue use. Explain that on small country lines there is not much traffic, and so not much passengers' luggage to carry.
(10) *Luggage van*. This is for the passengers' luggage. (11) *Porters* put the luggage into these, after labelling it; and also take it out.	(10, 11) Ask how the luggage is *marked*. (Labelled for place to which it is travelling.) When it arrives there, it is put out on the platform till claimed by the passenger, who looks out for it himself.
(12) *First class* carriages are fitted up much better than third; but even the third are very comfortable.	(12) Point out that more room, and better cushions, and arms to the seats, are given in the first class carriages for the extra expense.
(13) In winter *foot-warmers*, filled with hot water for the feet, are provided in all classes.	(13) Give description of a foot-warmer, and compare it with hot-water bottle used in bed, and tell how it is filled.
III. Parts and Uses of a Carriage— The top is called the "*body*"; the framework, the "*under*"-carriage. At each end of the under-carriage are two *buffers*, and a strong iron *hook* and *chain* called "*coupling-irons*".	III. Get as many parts and particulars from children as possible. Draw diagram of hook and coupling-iron on the black-board. Notice that *coupling-irons* are easily hooked together, and that they are double (two sets) in each carriage.

NOTES OF LESSONS—A RAILWAY TRAIN—*Continued.*

Matter.	Method.
Each carriage has *axles* on which are the wheels. To each axle is a pair of *springs*. The *wheels* are sometimes solid and sometimes filled up with wood. The edge of the rim of the wheel is raised to keep it on the line.	Point out the *axle*, and show its use by the illustration of a cart-wheel. Show that wheels need oiling to run easily, etc., and how this is done. Show drawing of *wheel*, and compare with tram-wheel, cart-wheel, bicycle-wheel, etc.
There are "*footboards*" or "*steps*" to each carriage, for safety in getting in and out, etc. These are like steps in carriages and buses.	Why do we use *footboards*? (To prevent passengers stepping between carriage and platform; and to lessen the distance in getting up and down.)
The body is divided into five parts or "*compartments*"; each having doors, seats, windows, curtains, hat-racks, signal-cord, steps, etc.	Get as many of the divisions and internal fittings from the children as possible, and also their uses.
Some carriages are "*travelling post offices*". In these letters are "sorted". They are open at each end so as to allow of passing from one to another. *Pullman cars* are run on some trains: these provide for sleeping and dining.	Explain "*travelling post office*", and also "Newspaper train". Show picture of *Pullman car*, and give a description of its internal fittings and arrangements. Note that an attendant travels with each of these.
IV. How Worked— By a driver, a stoker, and a guard, with *porters* at all the stations to bring in and remove the luggage, etc., and ticket collectors to take, examine, and clip the tickets.	IV. Get the work of each from the class. Show the necessity for *porters*, and notice the convenience of *tickets*; and compare these with the *stamps* used for post office work.

7. NOTES OF LESSONS—A RAILROAD.

Apparatus.—Pictures of railway line, railway bridge, viaduct, tunnel, station, signal, and signal box.

Matter.	Method.
I. Introduction— There are different ways of *travelling*—*walking*, *riding* on horseback, *driving* in carts, carriages, etc., and *sailing* in ships (driven by wind or steam).	I. Suppose I wish to go to the seaside, how could I go? (By *train*.) Where do trains run? (On the *lines*.) What are the lines called? (*Railroads*.) Why are they so called? (Because they are made of *rails*.)

NOTES OF LESSONS—A RAILROAD—*Continued.*

Matter.	Method.
II. Starting Place, or Station— *Stations* are of different *sizes*; some large (in great towns), others small (in villages). A station has a *ticket office, waiting* (and sometimes *refreshment*) *rooms, platform, seats, signal boxes, telegraph offices,* etc.	II. Ask children to give as many of these as possible, and the *uses* of each. Why is a town station larger than that of a village? (Because it has to do more work.) Show a picture of a large station, and explain the meaning of "*traffic*" (goods and passenger).
III. The Lines— The train runs on a pair of *lines,* made of iron or steel rails like tram lines, but without the grooves. These are fastened to thick blocks of wood called "*sleepers*", held firm on these by "*chairs*". The rails are twenty-four feet long, and fastened firmly to the sleepers. Their ends do not touch, because of their stretching or expanding in summer. Here and there are "*switches*" to turn the train from one set of lines to another to let other trains go by, and to get on to other lines.	III. Illustrate by a *tramcar* running on tram lines in towns. Draw a picture of a "*chair*" on the blackboard; and show how the rail is held firmly in place by the pieces which project. Show how the chair is fastened to the *sleeper* by large *bolts.* Note that the sleeper is bedded into the earth. Why? (To keep it in place.) Give some measure to show how long twenty-four feet is. Show that heated iron expands, by reference to the wheelwright putting a red-hot "tyre" on a wheel. Explain what the "*switching*" is for.
(*a*) *Main and Branch Lines*—*Main* lines are those between great towns like Leicester and London. *Branch* lines go from these to smaller towns and villages on either side of the main line.	(*a*) Show the difference between *main* and *branch* lines by reference to a high road, and smaller side roads or paths from it. The branch lines have less traffic, both in goods and passengers.
(*b*) *Junctions.*—These are places where different lines meet. They are often near large, busy towns. There are often a great many lines here.	(*b*) Draw a rough plan of a *junction* on blackboard, and explain this by reference to cross roads, and side streets meeting in a large town.
(*c*) *Signal Posts and Boxes.*—These are placed at certain points along the line. The posts have *arms,* which can be moved. Where the "block" system is used, and it is now almost universal, when the arm is level (*horizontal*), the train must stop; if sloping (*inclined*), the line is clear. Formerly there were *three* signals employed instead of two, the horizontal, inclined, and vertical; but the latter has now been disused almost everywhere for some time.	(*c*) Draw a sketch of a signal post on blackboard, and show by means of two rulers how the *arm* works. Make a simple model of a signal post from two strips of wood fastened by a tin-tack. Show how a *man* could use his arm or arms as signals. How does the signal arm move? (A man in one of the boxes pulls a wire fastened to the arm.) Explain that the coloured glass moves with the arms.

NOTES OF LESSONS—A RAILROAD—*Continued.*

Matter.	Method.
The line passes over rivers and roads by *bridges*; over hills through *cuttings*; and through mountains by *tunnels*.	Ask how train goes over *rivers* and through *mountains*. Tell briefly how a tunnel is made. Ask children where there is a tunnel near the school.
IV. Uses of Railway— (1) For *passenger* traffic. (2) For *goods* traffic.	IV. (1) Deduce *uses*, and ask what different kinds of goods are carried by railway. (2) In villages refer to the use of the carrier's cart.
V. History— Before the locomotive steam-engine was invented, *goods* were taken by *road* or *canal*. This was very slow and dear work. People travelled in coaches, changing horses at different places on the road, and often meeting with accidents.	V. Show a picture of a "*stage coach*", and refer to the length of time taken to travel by this, and compare it with railway. Refer children to nearest canal wharf. Heavy cheap goods, such as coal, bricks, wheat, sugar, etc., often still come by canal.

8. A SHIP.

INTRODUCTORY SPECIMEN LESSON.

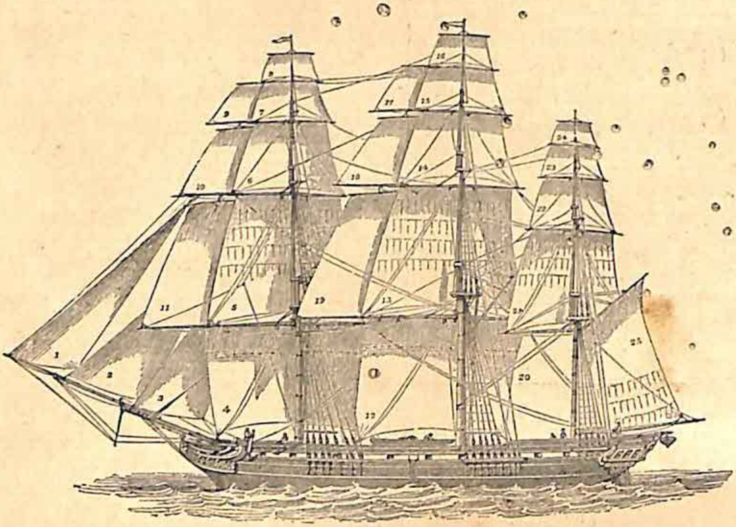
I. Introduction.—All English boys appear to be fond of ships, and of the sea. That is one reason why our sailors are the best in the world. You may see how fond boys are of the sea by their making toy boats, to sail on ponds and streams; and by their pleasure in going on the sea in boats at the seaside in holiday time.

II. Parts of a Ship.—The body of the ship is called the **hull**, because it is the **hole,** or **hollow**, into which we put the load, or **cargo** which the ship carries. This hull is covered by the **deck**, which is a floor to walk on, and a ceiling, or roof, over the hull, to keep the goods there from waves and wet. Part of the hull is shut off from the goods, and made into little rooms called **cabins**, and here the sailors and the passengers eat and sleep.

When you stand on the deck, and look in the direction the ship goes, you face the **bow**; and the part behind you is the **stern**.

Besides, the ship has **masts**, generally made from tall, straight pine-trees with the branches and roots lopped off. These are fixed

firmly to the deck and hull. The masts have cross-pieces coming off from them called **yards**; and upon the **masts** and **yards** the **sails** are spread out. The wind blows the sails, thus making the ship go through the water. Sometimes, besides wind, or instead of it, the ship goes by steam. If so, she is called a **steamship**; but if she only goes by means of the wind, she is called a **sailing-vessel.**



Sails of a Full-rigged Ship.

1, Flying jib; 2, jib; 3, fore-topmast staysail; 4, fore-course (or fore-sail); 5, fore-topsail; 6, fore-topgallant sail; 7, fore-royal; 8, fore-sky-sail; 9, fore-royal studding-sail; 10, fore-topgallant studding-sail; 11, fore-topmast studding-sail; 12, main-course (main-sail); 13, main-top sail; 14, main-topgallant sail; 15, main-royal; 16, main-sky-sail; 17, main-royal studding-sail; 18, main-topgallant studding-sail; 19, main-topmast studding-sail; 20, mizzen-course (cross-jack); 21, mizzen-top-sail; 22, mizzen-topgallant sail; 23, mizzen-royal; 24, mizzen-sky-sail; 25, spanker or driver.

III. Kinds of Vessels.

—There are many different kinds of vessels, and these have different names; and those used in one country are not all like the ships of another country.

(*a*) **Small boats.** Thus, we have boats which are **small**; either with, or without, masts and sails; or the masts can be put in and taken out as we please. Such are some fishing-boats, pleasure-boats, sailing-boats, and little boats belonging to larger ones used to take the sailors to and from the shore when the ship comes to land.

(*b*) **Fishing smacks.** Others are "**smacks**", **luggers**, or larger

fishing-boats that can stand against the strongest winds that blow, if they have plenty of sea-room, and there be no rocks near.

Brigs, etc. When a ship is still larger, and has fixed masts, it is called a **brig**, or a **schooner**; or, if it is used in war, it is called a **man-of-war**, or an **ironclad**. Our old men-of-war used to be made of **oak**; those we have now are made of timber, covered over with plates of **iron** or **steel**. This is why the latter are called **iron-clads**. Sometimes the plates are a foot and a half thick, to keep out cannon balls in battles on the sea.

IV. The English Navy.—As we have the sea all round us, we do not want so large an army as they have in France and some other countries. We are quite safe all the while we have a good **fleet** of ships to keep the foe from bringing soldiers to fight against us on the land. That is the reason why we take such great care to build a good fleet, and keep it up as well as we can. A **fleet** is the same as a **navy**, and means a large number of ships.

But we have also ships which carry **goods** to and from us and other people, or which carry on **trade** with them.

9. NOTES OF LESSONS—SHIPS.

Apparatus.—Diagram of ship; model if possible (a small, simple one can be made by the teacher or by a member of the class).

Matter.	Method.
I. Introduction— Refer back to last lesson for the different modes of travelling on land and water: viz., by railways, carts, carriages, boats and ships.	I. Show the children pictures of a *boat* and of a *ship*; and ask what each is called. Ask what children have seen a *barge*: use this as a type, near a canal, in the absence of boats.
II. What a Ship is— A ship is a large boat, or "*vessel*", made to float on water, with some means of moving it through this (by *oars*, *sails*, or *steam*). It is made of wood, or iron, or steel.	II. Get as good descriptions of boats and ships from class as possible, and add together the different characteristics given by each child, to make a summary.
III. History— The first boats were generally made from *trees* chopped down, by burning out all the middle, so as to make a hollow inside. Sometimes canoes were made, as by the Ancient Britons, of plaited twigs, with skins outside. *Sides* were	III. Describe, or show a picture of, a savage burning a hollow in a tree-trunk with fire and red-hot stones. Do the same with an Ancient Briton and his "coracle", or boat of wicker-work covered with hide; and a modern merchantman or ironclad.

NOTES OF LESSONS—SHIPS—*Continued.*

Matter.	Method.
next added to these, until *planks* were used for the hull instead of tree-trunks; and then ships were made much larger. Now we build ships of *wood*, *iron*, or *steel* up to 500 feet long.	Give a measure of this length by pacing the school floor.
IV. Particular Description—	
(*a*) The main bulk of a ship is called the body, or "*hull*". Inside of the "hull" is the "hold". This holds the goods. The bottom of this is called the "*keel*"; it stretches from front to back, or from "*stem*" to "*stern*", and is like the backbone of an animal, and, like it, has *ribs* fastened to it. The forward part of a ship, where the planks incline inward till they meet, is called the *bow*.	IV. (*a*) Point out on diagram, picture, or model, the different parts named, and label them on the model with gummed slips. Build up a drawing of a ship, beginning with the *keel*, next adding the *ribs*, then the *bow* and *stern*.
(*b*) The *sides* of a ship are covered with *pitch* and *paint* to keep out the water; and tow is driven in between the seams of the planks for the same purpose.	(*b*) Explain to children the way sailors "caulk" the decks and beams; and also how the sides are *tarred*, or *painted*. This is done to make them watertight.
(*c*) The *rudder* is mostly placed at the stern, and acts like the tail of a fish or bird. It is very small compared with the size of the ship; but yet with it we can easily steer or guide the ship. It is turned by a bar or "*tiller*"; or by a *chain* fixed to a "*wheel*".	(*c*) Draw a diagram of a ship's wheel, and show how it is used to wind a chain, and so turn the *rudder*. Refer to the simpler method of turning the rudder by a lever in barges.
(*d*) The floor of a ship is called the "*deck*". The rooms for passengers and officers in a ship are called *cabins*; and the sailors' sleeping places, *berths* or *bunks* and *hammocks*.	(*d*) Tell children of the sleeping arrangements, hammock, etc., in ships, and describe each of these to class.
(*e*) The *masts* are upright poles, to which the sails and ropes are fastened. The cross-pieces on the masts are *yards*. The ropes are called the *rigging*.	(*e*) By rough sketches on blackboard show that the *masts* are *jointed*; and also that they are supported by ropes. Why jointed? (For greater strength.) Note the gradual tapering of the masts. Roughly sketch the *sails* on the masts, and show how they are fastened and managed, and write the names on them of "mainsail", "foresail", "topsail", and "jib".
The ship carries a *compass* for steering purposes.	Show a compass, and tell how it is used.

NOTES OF LESSONS—SHIPS—*Continued.*

Matter.	Method.
V. How Made— Ships are generally made of very hard *timber* (oak or teak). Some are made partly of wood (oak or teak), and partly of *iron*; others wholly of iron plates rivetted together; and, lastly, some of *steel*. The wooden hull is covered with copper to keep it clean.	V. Why should the wood be *hard*? (To wear well.) Why is *iron* used? (For strength.) Why do iron ships float? (Show that hollow vessels, like a bottle, a cup, etc., will float, so long as they are not heavier than the water displaced.) Drop a piece of tin in water; then hollow it out, and let it float.
VI. How Worked— (1) By *wind*:— Sailing vessels, as colliers, merchantmen, etc., where time is not of very much consequence. (2) By *steam*:— (*a*) Screw steamer, with a screw. (*b*) Paddle-steamer, with paddle-boxes. Both are used in the great "Liners", or ocean-going steamers. Screw go faster than paddle-steamers, but are not so steady. Most of the new ships being built are now steam-ships, as these can make two voyages in the same time as sailing ships make only one. The ship is kept at rest near the land by means of an anchor.	VI. (1) and (2) Which go *faster*—sailing or steam ships? (*Steam*—even up to twenty-five miles an hour.) Which are *cheaper* to work? (*Sailing*; but their voyages last longer.) Why? (Coals and engines are expensive.) Can sailing vessels always proceed? (No.) Why? (Because there may be *no* wind, or *too strong* a wind, or a wind *against* the ship.) Steam ships can go on in any weather. Draw diagram of a paddle and of a screw, and show where in the ship each is placed. Draw a diagram of an anchor, or show one used as an ornament.
VII. By Whom Worked— Captain, mate, and sailors, steward, etc. In steam-ships, engineers and stokers are also required. The sailors are sometimes called the "*crew*". All these have to learn their trade, and undergo great risk to life and limb.	VII. Which is the head officer? (*The Captain.*) What is the work of the *sailors*? (To trim the sails, etc., at the orders of the captain and officers.) And of the *steward*? (To give out the stores.)
VIII. Speed— Some of the fastest *vessels* can steam from 16 to 25 miles an hour. Fast *trains* run 40 to 60 miles an hour. Fast *horses* run 8 to 10 miles an hour.	VIII. Compare speeds of *vessels* with that of *horses*, *trains*, etc. Sailing vessels are much slower than steam ships, but the latter with sails are being more and more used, as the sails help the steam, and also steady the ship.
IX. Uses of Ships— Ships are very useful; we could not now do without them:	IX. Get as many of these as possible from the children themselves.

NOTES OF LESSONS—SHIPS—*Continued.*

Matter.	Method.
(*a*) For *trade*, that is, to carry *goods* and *passengers* from one place to another.	(*a*) Ask for different articles brought by ships to England. (Tea, sugar, etc.)
(*b*) To carry *soldiers* and *sailors* to *war* against another country.	(*b*) Show picture of old wooden *man-of-war*, and of a modern *ironclad*, with soldiers and sailors on them.
(*c*) For *protecting* our *ports* and *coasts*. (By men-of-war, ironclads.)	(*c*) *Gunboats* cruise round our coasts, to warn us against enemies, and preserve fishing-grounds, etc.
(*d*) For exploring other countries, going up rivers, across seas, etc.	(*d*) Tell of Columbus discovering America, and of Arctic navigators in search of a North-West passage.
X. Dangers— (1) From *storms*. (2) From *rocks*. (3) From *collisions*.	X. Explain and enlarge on each of these items of peril to ships.

FOOD-STUFFS.

10. NOTES OF LESSONS—WHEAT.

Apparatus.—Wheat, barley, and oats in grain; a whole wheat plant (root, stem, and ear); bran, flour (white and whole-meal); chaff; wheat grains growing in a "saddle" or "loop" in jar of water (set previously). Tall wild grasses; one with the ears arranged in "*spikes*", as in wheat; another on separate stalks, "*panicle*", as in oats; and another "*bearded*", as in barley.

Matter.	Method.
I. Description of Plant—	
(*a*) *Root*. This consists of fine threads, like those of other grasses, and is very long, to penetrate to great depths of soil.	I. (*a*) Get from children as many of the parts of wheat as possible. Compare and contrast the wheat plant with other grasses, by showing all these together.
(*b*) *Stem*. The stems are *tall* for exposure of flowers and seeds to the sun; and *hollow* and *jointed*, for the purpose of giving strength against winds and wet.	(*b*) Why are stems *long*? (To give flowers and seeds sun and air.) Show a dried stem (straw), and note that it is *hollow*; point out the *joints* in this.
(*c*) *Flower, fruit, and seed*. The *flower* is found at the top of the stalk in wheat and grasses. The *seeds* (grains of wheat) are protected by *husks* (chaff) in what is called the "ear". This consists	(*c*) Show the flowers on several grasses. Show ear of wheat. Point out the grains. Make enlarged drawing of a *spike* on blackboard. Pull off the different coverings of the grain.

Notes of Lessons—Wheat—*Continued.*

Matter.	Method.
of a great many separate grains, placed side by side, and opposite, forming what is called a "*spike*".	Show the class the naked flower-stem after the seeds have been pulled off. Compare this with those of oat and barley plants.
II. Description of Grain— Each grain, or seed, is *oval*, *hard*, *round* on one side, and flat and *grooved* on the other. The outside is yellow or brownish, and is called the husk (bran). Most seeds have some sort of covering to keep the wet from them since they fall on the damp ground.	II. Make drawing of a grain on black-board, and show some grains. Point out the shape and position of the *groove*. Compare with other seeds. For white flour the husk is taken off. Of what use is bran? (As food in brown bread, and for cattle, to make pin-cushions, bran poultices, etc.)
III. Ground Wheat— *Grinding*, or "*milling*", is done in large mills, between great rollers and "wheels". In wild countries men grind corn between *stones*. Ground wheat is called flour. This is a whitish powder. If the husk is ground along with the grain it makes "whole-meal", for brown bread.	III. Show picture of a *windmill*, and make a rough drawing of "*millstones*". Show how these act, and pound a few grains. What is the powder called? (Wheat flour.) Point out the husk, and show this is not ground so finely as the flour, but is in yellowish *scales*. Pick a few of these scales out of whole-meal flour.
IV. Uses— (*a*) The ground wheat, or *flour*, is useful for— (1) *Bread*, used at every meal. (2) *Puddings* and pastry, used mostly at dinner. (3) *Biscuits*, much used as an article of food, and specially by sailors. (*Dog biscuits*, a special kind.) (4) *Gruel* and paste: the starch is very "*sticky*" when boiled. (5) *Macaroni*, put into soups, and made into puddings.	IV. (*a*) (1)-(5). Get as many of these uses as possible from the class. Ask how *bread*, *puddings*, *gruel*, *paste*, *pastry*, etc., are made. Why are biscuits so useful to sailors? (They are dry and will keep a long time.) What is macaroni? Show a piece.
(*b*) *Bran* is useful for— (1) Stuffing pincushions, etc. (2) As food for pigs, sheep, etc., to fatten them. (3) For poultices, to keep the part hot to which they are applied.	(*b*) (1)-(3) What animals is bran used for feeding? (Ducks, rabbits, pigs, etc.) How do we make poultices with it? (By putting it in a bag into a hot oven, or by steeping it in boiling water.)
(*c*) *Straw* is used for bedding cattle, making hats, etc. Its uses arise from its properties of being *light*, *cheap*, *dry*, and throwing off *rains*; also *warm*, easily *dyed* and *bent*. Wheat straw is the strongest and tallest.	(*c*) Ask the children for the various uses of *straw*. (1) For *bedding* cattle and pigs. (2) For making *mattresses*. (3) For *thatching* roofs. (4) For *plaiting* into hats and bonnets. (5) For *feeding* lean (store) cattle and pigs. Point out the leaves on the straw stems.

NOTES OF LESSONS—WHEAT—*Continued.*

Matter.	Method.
V. How obtained— In spring and autumn the farmer, after *ploughing* and *harrowing* the ground, sows the seeds by hand (broadcast), or by a *drill.* The ground is then *harrowed* and *rolled.* In the spring the stems begin to grow tall, and in the summer the grain is formed, and in autumn the plant ripens, and is cut down into bundles called *sheaves.* The wheat grain is sold to the miller, who grinds it into flour.	V. Give a word picture of *ploughing* and *harrowing*, and show pictures of these in reading books. Show how a man would scatter seed by hand. (Irregularly.) How would a *drill* sow it? (Regularly, in long lines or "drills".) What colour is ripe wheat? (Yellow, golden.) Make drawing of *sheaves.* How is the wheat cut? (By reaping machines, and by sickles and scythes.)

11. NOTES OF LESSONS—BREAD AND BREAD-MAKING.*

Apparatus.—Flour, salt, water, barm or yeast.

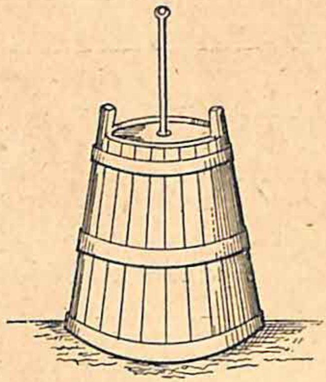
Matter.	Method.
I. Introduction— Repeat some poetry on bread-making, *e.g.*, "*Who can tell how bread is made?*"	I. Ask what we eat at most of our meals, but specially for breakfast and tea. (Bread.)
II. Of What Made— It is made of *wheat-flour*, *salt*, *water*, and *yeast*, or barm. Instead of wheat-flour we might have the flour of oats, barley, rye, maize, and even of rice and chestnuts, with some wheat-flour for "binding" the latter together. Wheat-flour may be either white, or with bran in it (*whole meal*).	II. Get as many of the different ingredients from the children as possible, and supply the rest. Ask why *salt* is used? (To give the bread "taste".) Why *yeast*? (To make the bread spongy or light.) Why *water*? (To make the flour, etc., mix into a firm paste.) Ask what other flours might be used besides that of wheat, and what children have eaten *brown bread* and *oat cake.*
III. How Made on a Small Scale— Some *flour*, with a sprinkling of *salt*, is put into a pancheon. To this is added *yeast*, mixed with lukewarm *water*. It is now put into a warm place, to "*work*", and "rise". After this it is made into "dough", or paste, by adding more water. If the hand can be	III. Have the necessary articles present for this bread-making before the class. Note that water, if too *warm*, will spoil the "yeast" or "barm". Why do we want bread to rise? (To make it light, spongy, and soft, and to prevent it from being "sad".) Ask for different *shapes* of loaves, as tin-bread, cottage-

* For Girls' Schools taking Domestic Economy this and the preceding food subjects are treated in fuller detail in "The Teacher's Manual of Lessons on Domestic Economy," by the same publishers.

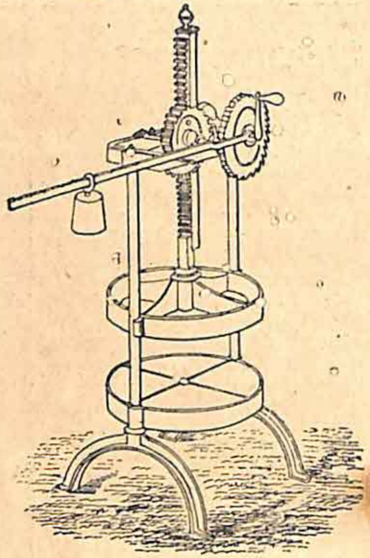
NOTES OF LESSONS—BREAD AND BREAD-MAKING—*Continued.*

Matter.	Method.
drawn out of the dough without any sticking to it, the dough is well mixed. It is covered with a cloth for a time to let it rise. The dough can now be weighed and shaped according to wants.	loaf, batch-cakes, etc., and draw their shapes on the blackboard. Mother makes the loaf no particular *weight*, but baker does, about 2 or 4 lbs., as he has to sell it by weight, according to law.
IV. How Made on Larger Scale by Bakers— The *baker* has to do just the same things as mother, but deals with larger quantities. The "*sponge*" is first made, and put into a "bin" or chest, and mixed with more flour. Potatoes are sometimes added. Point out the operations on picture of "Trades". (Baking.)	IV. Describe the "*setting the sponge*". Why are *potatoes* used? (To make the bread light.) What must we first do to the potatoes? (Wash, and boil them in the oven.) Notice the great heat in the bakehouse. Describe the "kneading" of the dough; and show how each loaf is made. Point out that the "sponge" is "set" the night before to give it time to rise.
V. Kinds of Bread— There are several kinds of bread. (*a*) The common, or *white*, that most used. (*b*) *Brown*, made of bran and white flour. (*c*) *Whole-meal* bread made of the ground wheat. (*d*) *Aerated* (with no yeast in it). This can be bought only in a few places (London, etc.). (*e*) *Milk bread* (mixed with milk and water).	V. Ask children for commoner sorts, and supply the rest. (*a*) What is the *common* made of? (Flour.) (*b*) What is *bran*? Show difference between this and whole-meal. (*c*) Tell class that this is better for food than the other two. (*d*) Explain that aerated bread is made by pumping air into the dough. (*e*) What colour will milk make the bread? (White.)
VI. Kinds of Flour— There are several kinds of white flour—"*firsts*", "*seconds*", and "*thirds*".	VI. Which will be dearest, and which the cheapest? Most bread is made of "seconds" flour.

12. NOTES OF LESSONS—MILK.*



Upright Churn.



Cheese Press.

Apparatus.—Some new, and skimmed milk, and cream; a bottle and tumbler; some vinegar; a strip of coarse canvas, tissue paper, clean calico, a cork, a coin, and water.

Matter.	Method.
I. Properties— It is a *white liquid.* We cannot see through it (*opaque*). It is sweet to the taste, and soft to the touch. It has a *faint smell* and is *greasy*. New milk has *cream* in it; skim milk little or none. The cream rises to the top. It is generally obtained from the cow, but sometimes from the goat, especially in other countries. It is like chalk and water in colour, but not in taste nor smell. It leaves a stain of grease (cream) if dropped on tissue paper. It contains very much water, that is, it is a *liquid*, but has *solids* in it. This is because it is made out of the cow's food (grass, hay, etc.), which are solids, with much water in them.	I. Show a glass of milk, and one of water. Let children tell properties from observation, and supply any left out. Ask children the effect of spilling milk on clothes. (It leaves a spot of grease.) Why called "skim" milk? (The word means skimmed.) Show some. What other name is given to it? ("Old" milk.) Why does the cream rise? (It is lighter than the rest.) Illustrate by cork and coin in water. Ask what animals give milk. (Cow, goat, etc.) Explain word "liquid" as the name of something that flows or "runs", like tea, water, etc. Things that are not liquid are mostly *solid*, as ice.

* *Vide* footnote to preceding article.

NOTES OF LESSONS—MILK—*Continued.*

Matter.	Method.
II. Uses— It is a very wholesome and nourishing *food*, taken largely by invalids and babies. It is easily *digested*, and contains all the ingredients of a "perfect" food. From milk we get two valuable products—(*a*) *butter*, (*b*) *cheese*. It is used to drink, and for making milk-puddings; and the whey and butter-milk are used for feeding pigs.	II. Show the class that it must be very *strengthening*, as most *young* animals they know (cow, sheep, etc.), by whom it is chiefly drunk, live on it entirely at first. Enquire if babies can live on it. (Yes.) This shows that it must contain all we want to nourish our bodies. Show that we could not live on one kind of any other food.
(*a*) **How Butter is Made**— The milk is taken to the dairy, and allowed to "stand" for a time till the cream rises, which is then skimmed off. Then the cream is *churned*, or made into *butter*. This is then beaten with two pieces of wood into shapes, and each piece weighed. The shapes of the *pats* and *rolls* are various.	(*a*) Put a little milk into a warmed jug and shake it; we find that it divides into two parts— (1) Small lumps, like *butter*. (2) A liquid called "*butter-milk*". Show a picture of a churn, and explain how it is used. Show by beating a piece of modelling clay how butter is shaped; and refer to butter shops in the town showing pats of butter.
(*b*) **How Cheese is Made**— If we put something into milk that will turn it "*sour*," we shall get a "solid" substance called "*curd*", and a "liquid" called "*whey*". The *curd* looks like "cream cheese", and the *whey* like water, but rather bluish in colour. The *curd* is the part which turns to cheese. The curd is pressed into shapes, and baize, linen, canvas, or calico is put round it to keep it in shape. The *whey* is used for fattening pigs. When we drink milk it turns to "*curds*" in the stomach.	(*b*) Show a piece of cheese, and get from the children as far as possible how it is made. Put some vinegar into milk to turn it *sour*. Pour off the "*whey*" and show the "*curd*". Point out the colour of the curd; and tell how the cheese is coloured. Notice the blue tint of the whey. Show a piece of cheese with baize, linen, or canvas round it. Ask where cheese is made. (In the country.) And why? Get children to name as many kinds of cheese as possible.
III. How Spoiled— (*a*) By *improper food* given to the cow; some milk in winter (when there is no grass) tastes of turnips. (*b*) By *bad smells* from the cow-house, manure heaps, dirty drinking ponds, etc. (*c*) From *want of cleanliness*, especially from dirty milk cans. (*d*) By *turning sour* from *standing*, or from *thunderstorms*.	III. (*a*) Ask the class why turnips, instead of grass, are given to cows in winter. (*b*) Place a cut onion under a glass cover with saucer of milk: the latter acquires the taste of the onion. (*c*) Point out the great need, therefore, of washing milk cans in *clean* water. (*d*) Milk should be *boiled* to prevent this.

13. TEA.

SPECIAL INFORMATION FOR THE TEACHER.

I. Where Grown.—The tea plant is a native of China, Japan, and Siam; and has been acclimatized in Ceylon, Assam, and India proper. The finest tea shrubs grow in the island of Niphon, and close to the capital of Japan (Jeddo or Yeddo). The leaves of these furnish the "Imperial" tea, the use of which is restricted to the Japanese emperor and his household.

II. Kinds.—(*A*) The chief varieties of black teas are: Bohea, Congou, Souchong, and Pekoe.

(*a*) Bohea is of the poorest quality, and derives its name from a Chinese province of the same name.

Tea Plant.

(*b*) Congou is superior to Bohea, but of larger leaf. The word "congou" is Chinese, and signifies "much care".

(*c*) Souchong is a superior tea, the word "souchong" in Chinese signifying "a small and good thing". This is not largely grown, and only the best and youngest leaves of it are picked; so that not much of this is imported into Europe.

(*d*) Pekoe is so called from the district from which it is exported. It consists of the tenderest leaves of tea trees, three years old, in bloom; and is mostly used in the northern countries of Europe.

(*B*) The chief varieties of green teas are: Single, Hyson, and Gunpowder.

(*a*) (*b*) Single and Hyson are so called from the provinces from which they are procured.

(*c*) Gunpowder is so called because of the smallness of the leaf, like the grains of gunpowder.

The differences between black and green teas are due to:

(*a*) The nature of the soil,
(*b*) The mode of culture, and
(*c*) The manner of drying.

III. How Cultivated.—The tea plant is cultivated upon hill slopes, and, as the shrub grows very slowly, the leaves are not picked for the market before three years' growth has been completed. The bush is then about two and a half feet high. In seven years, by which time it has attained its mature growth, it reaches nearly six feet in height.

The plant is grown from seeds; and the young seedlings are planted out at a distance of five feet apart, and well watered and tended. The soil chosen is one that is light, rich, and loamy, where there is plenty of sun and air, mostly on the sides of hills facing the south and south-west.

IV. How Prepared.—As soon as the leaves are picked they are put into flat baskets, and exposed to the air or sun.

They are then dried in small quantities at a time in vessels heated over a fire. During this process they are stirred by the hand to prevent scorching.

They are again rubbed by hand over a charcoal fire. When thus properly dried they are spread out on a table, and the curled, yellow, damaged, withered, and coarse leaves picked out by hand.

14. NOTES OF LESSONS—TEA.

Matter.	Method.
I. Introduction— Tea was first brought into England more than two hundred years ago, when it cost from £6 to £10 per lb. Twenty years later the merchants who had the sale of it brought in nearly 5,000 lbs. It was taken into *France* at a still earlier time. Tea-drinking in *China*, where the tea plant was first grown, is of much older date than here.	I. It is said that in England when first imported the tea leaves were *eaten*, and the water in which the leaves had been boiled thrown away. Point out to the class that tea is not so much used in France as in England, *coffee* taking the first place there; but that in *Australia* tea is more largely drunk than even with us. Tell the class that the *Russians* are also very fond of tea.
II. Description and Cultivation— The tea plant is a low, bushy, evergreen shrub, with dark green, hard, glossy *leaves* like those of the *laurustinus*. It bears many single, white *flowers* like those of the *dog-rose*. It is best grown, or "cultivated", on sunny slopes, and may be reared wherever the climate and soil suit it, especially in *India* and *China*. The plant is grown or "raised" from *seed* sown in spring. The	II. This part of the lesson should be illustrated by pictures of the tea-plant, of a tea-garden, and of tea-curing; and by green or dried *laurustinus leaves*, and the *flowers* of the *dog-rose*; and by *specimens* of green and black teas. Tell the class that the countries where the tea comes from are warmer than England, but not the very warmest of all. Explain the ways of raising and transplanting seedlings, by reference to the

NOTES OF LESSONS—TEA—*Continued.*

Matter.	Method.
young plants, or *seedlings*, are next year transplanted in rows about a yard apart, and at last these grow to a height of from three to six feet. The *first* gathering of buds and young leaves takes place in early spring; and this gathering gives us the choicest or best teas for the market. *Later* pickings—of full-grown leaves—give larger, but inferior teas. The plants last for about ten years. *Black Tea* is obtained by putting the leaves in heaps in the air for one or two days, afterwards rolling them by hand, and drying and roasting them over a slow fire. *Green Tea* is obtained by drying the leaves at once as soon as gathered.	cultivation of cabbage plants, asters, and other annual flower plants similarly treated in gardens in this country. Tell the class that the Chinese usually keep the first pickings for *themselves*, or for the *Russians* who are supplied by land transport on camels, and down the rivers. This tea fetches very high prices on account of its fine quality, and because of its scarcity and the greater expense of "curing". To illustrate the "*curing*" of tea, serve the small leaves of the privet, box, etc., in the same way as tea leaves are served, in drying, rolling, etc. Let one of the children in the class assist in these exercises, to interest the class generally.
III. How to make Tea— Put the proper quantity, about one teaspoonful for each person, into a *warm* teapot. Pour upon this a sufficient quantity of *boiling* water, and serve almost at once, giving little time to "draw", "mash", or "brew". To get out its best taste it should be flavoured with lemon, but not mixed with milk, cream, or sugar. This is the way the *Russians* make tea. But the commoner way of making tea is to give time to draw out the "strength", and to add the last mentioned articles to make the flavour nicer.	III. The "goodness" of the tea is brought out by *boiling* water. Illustrate this by making a similar infusion of *senna* from senna leaves. Point out that the teapot is first *warmed* to prevent its cooling the water. Explain that if the tea "stands" in long brewing, a rough taste is brought out by the hot water, and that illness is sometimes brought on by drinking *too much*, or *too hot*, or *too long-mashed* tea. Tell class that "*tea tasters*", who try teas before they buy them for their employers, never use milk or sugar with the tea they *taste*, or *test*.
IV. Properties— There is no *food* proper in tea; and even if there were, the small quantity in one spoonful of the dry leaves to each person would be too small to count for much. Point out to class that *food* proper does for us one of two things, or both: (1) It gives *heat* to the body; (2) Or *builds it up*; or makes us grow. Tea clears and soothes the mind.	IV. Tea does not make us hot, in itself, though the hot water does. It also contains very little that can build up the body. But tea is very useful for all that, and much better than beer. Enquire from the class why this is so.

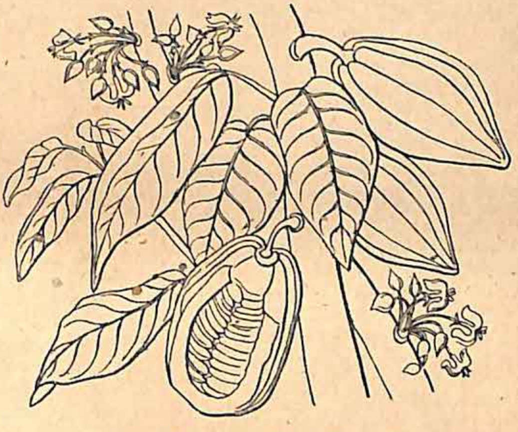
15. COCOA.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Description.**—The cocoa-tree, from which "cocoa" is obtained, is a native of the tropical parts of South America in the valley of the Amazon. It is distinct from the cocoa-nut palm, which yields the cocoa-nuts of commerce.

II. **Cultivation.**—The principal seats of its cultivation are in Bahia (in Brazil), Ecuador, and Venezuela, and in the West Indian islands of Trinidad, Grenada, Martinique, Cuba, and Guadaloupe,—in the New World: and in the Philippine Islands (Spanish), Java (Dutch), and Ceylon (English),—in the Old World.

The tree grows to a height of about twenty feet, and must be shaded from the direct vertical rays of the sun by other trees cultivated for that purpose. The "Bois immortels", which are grown for this reason, are hence called by the Spaniards, the "Mothers of the Cocoa".



Cocoa-Tree, with Pod and Flowers.

The cocoa-tree is best cultivated in the valleys, and on well-watered slopes, at an elevation of not less than five hundred feet, and protected by hills and shade-trees. Sometimes the latter are plantains and bananas.

Each tree produces about twenty-five pods, which are gathered mainly in two harvesting seasons;—in December and June, as they ripen and turn yellow.

The fruit ripens successively over a long period, not all at once. Each fruit-pod contains from thirty to fifty "beans" inside.

III. **Preparation.**—The pods are picked and broken by the labourers, and the "beans" carried in baskets to the "sweating", or "fermenting" house; they are then covered with banana leaves,

and allowed to remain fermenting for about five days. They are next spread out on large trays exposed to the sun. Meantime, women remove the thick brown mucilage, or gummy substance, adhering to the beans, by rubbing them in their hands. The dried beans are then placed in sacks for export.

IV. Properties.—Cocoa is a highly nutritious article of food, containing nearly every factor required in the growth and maintenance of the body. It has as much flesh-forming material in it as beef, due to the large proportion of highly nitrogenised vegetable principles it contains.

It is also a good tonic, so that it is invaluable to the sick patient.

16. NOTES OF LESSONS—COCOA.

Apparatus.—Cocoa-nibs, cocoa in cakes, powder, and sticks; chocolate, in chocolate creams and sticks, etc.

Matter.	Method.
I. What it is— The "*beans*", "*nibs*", or "*berries*", of the fruit of the cocoa tree which is grown in hot countries. It is one of the best and most *nourishing* of foods, especially when the large amount of fat in it is removed. It is most useful for *sick* persons.	I. Show class some *cocoa-nibs*, and break one of these to show the outside *husk*, and the brittle inside. Ask class when they have had cocoa and chocolate to *eat* and *drink*; and mention the names of the chief manufacturers. (Fry and Cadbury.)
II. How Grown— The trees are planted out on shaded *hill slopes*, and in *valleys*, where other trees can be grown by their side to *shelter* and *shade* them. The hot sun shining straight down on the cocoa trees would prevent them from bringing forth their fruit properly. The "*pods*" containing the berries do not all ripen together, but one after another, each tree bringing forth about *twenty-five* large "pods", with about *fifty* "nibs" in each pod.	II. Tell the children that the countries where cocoa is grown are very much *hotter* than England; and that the cocoa trees cannot do with so great heat. They have therefore to be *shaded*, and the cheapest way to do this is to grow rows of other trees between, so as to lose no ground. Show a picture of the plant and its pods. (Messrs. Fry and Cadbury will on application supply these *gratis* to schools.) K. Johnston also sells one.
III. How Prepared— (*a*) *The Harvesting.*—The first thing after the proper cultivation is to *gather* the pods as they ripen.	III. (*a*) Enquire what we do with *all* crops (wheat, peas, etc.) after they have been cultivated. (We gather them in.) Tell

NOTES OF LESSONS—COCOA—*Continued.*

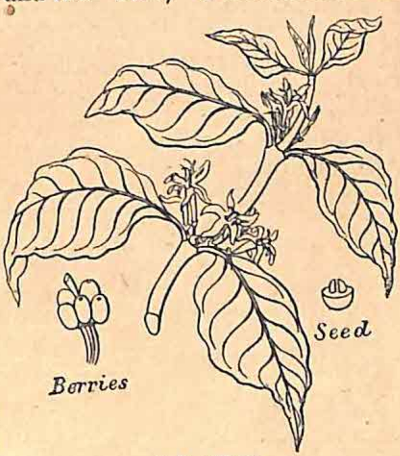
Matter.	Method.
This is done by the white men working in the cocoa plantation, assisted by the coloured natives. (*b*) *Fermenting.*—The next thing is to let the fruit remain for five days in the *sweating* or *fermenting* house, to *ripen* and *change*, so as to be fit for eating. (*c*) *Cleaning.*—Then the nibs are *cleaned* from all sticky substances clinging to them, and are afterwards *dried* in the sun. (*d*) *Packing.*—Lastly the cleaned, dried, and prepared cocoa-nibs are *packed* in sacks to be sent away or exported in ships to England and to other countries, especially to France, where very large quantities of chocolate are made from cocoa and sugar.	the class that in the countries where cocoa is cultivated there are still *natives* left who will work for white men. (*b*) *Fruits often change* after they are gathered: thus *apples* become sweet, *pears* "sleepy", etc. So, also, tell the children, the "*nibs*" change with keeping. (*c*) Refer to picture, and tell class that there is a *gum* in the pods round the nibs which has to be got rid of. (*d*) As the cocoa tree is cultivated for *other countries*, and mostly for us and the French, the nibs have to be sent away in *ships*. And as they are quite dry after being put in the sun, they can be packed up in *bags*, which are *light* and *easily* made.

17. COFFEE.

INTRODUCTORY SPECIMEN LESSON.

I. What it is.—Coffee is the seed or kernel of the fruit of an evergreen shrub, which is a native of hot countries.

The fruit is like our cherry, and the "**berry**" is like the stone of this. The tree has a straight **trunk**, and is kept pruned or clipped every year to about six feet high, to allow the berries to be more easily gathered. The **leaves** are rather oblong in shape, and broad and smooth like those of our bay tree.



Coffee Plant.

The **flowers** are many, white, and sweet-smelling; but only last for a few days. These are followed by "**berries**" about the size of a cherry, and in colour a dark red; the two hard, oval **seeds** inside give, when prepared, our coffee.

II. Cultivation.—The seeds are grown into plants, and these plants or seedlings are placed out seven or eight feet apart, on the sides of sloping hills in plantations well shaded by larger trees.

The shrub does not yield fruit until the second year. A tree in full growth will give three or four pounds' weight of berries.

When the berries are ripe, cloths are put under the trees and the fruit is shaken down on these: another way of gathering them is to pluck them off by hand.

III. Preparation.—The berries are put into bags and taken to the mill, where the outer skin is rubbed off by wooden rollers. They are then put into large sieves, so that the wind may winnow, or blow away, the dirt and leaves.

The next thing is to roast them in an iron vessel, which gives them a dark chestnut colour, and a nice flavour and smell. If they were not roasted, the berries would have hardly any taste or smell. They are then ground, and the powdered berries are lastly boiled in hot water, or have boiling water poured on them, which makes our coffee for breakfast.

IV. Brought to England.—A merchant first brought coffee into England more than 250 years ago; he also brought with him a servant who understood the way to roast the berries, and to make them into a drink. The first coffee-house was opened in London.

V. Uses.—As a drink, coffee is light and pleasant, and helps our food to digest. It nourishes the body. It also prevents us from becoming drowsy, often keeping a person awake several hours. This is very useful for people that want to work at night; but it would be a bad thing for those that go to bed and wish to go to sleep. Such people should not drink coffee just before going to bed.

It is also an excellent thing to drive away headache and to cheer up the spirits.

METALS.

18. GOLD.

INTRODUCTORY SPECIMEN LESSON.

I. What it is.—I dare say you have all seen something that is made of gold. And, as you do not very often see things made of this, you know gold must be very scarce, or that there is not a great deal of it to be had.

It is a metal; that is, it is one of those substances which we **dig out** of the earth, and which we can very often **draw out** into wire, as we can copper, etc. Metals can also in many cases be **hammered** out into thin plates, as gold itself can.

II. Properties.—Of all the metals, gold is the best:

(*a*) To draw out into **wire**. For gold wire can be made as fine as thread, as you see in the gold-thread which people weave into collars. Gold has been drawn out so fine that an ounce of it,—or about four times as much as would make a sovereign,—has been made into more than a thousand miles of wire. That would be more than enough to go from one end of England to the other and back again.

(*b*) To hammer out into **leaf**. It is thus made into the gold-leaf, or "gilt", that people stick on the letters and bindings or covers of books.

(*c*) Gold does not **rust**, but keeps its bright yellow colour. So it is used to make cups, spoons, watches, brooches, rings, chains, and other things which we wear for show or use.

(*d*) It is also made into **coins**, for as it is so scarce and dear it does not take up much room. You can easily carry enough money in gold to pay for a cow or a horse. But if you had the same money in copper or bronze,—as in "pence",—or even in silver shillings and sixpences,—you would have a great weight to carry.

III. How Obtained.—(*a*) **From rocks**; gold is found in the oldest and hardest **rocks**, which we crush to get it out.

(*b*) **Alluvial sources**, or we find it in **river-beds**, or where rivers have worn away the rocks, and the heavy grains of gold dust have sunk down, while the lighter sand and mud have been washed away. Gold is one of the heaviest of metals, and is nineteen times as heavy as water, and that is why it is left behind in these river-beds.

The places where gold is found are called "**diggings**", because people often dig down to get at it. It is found there either as **small grains**, or in lumps called **nuggets**. Once a large nugget was found which weighed as much as two sacks of coal, and which was worth many thousands of pounds. Think what a day's wage that was for the man who found it!

A great deal of gold is brought to England every year; but still we have not enough to use in our great trade, and so we use **paper money**, or **bank notes**, as well.

IV. Gold Alloys.—When gold is made up into coins, brooches, watches, and such things, we are obliged to **mix** with it other

metals **harder** than itself, for gold is **too soft** to use alone. It is mixed with **copper** and **silver**; and so some sovereigns are lighter in colour than others. These are those that have silver, instead of copper, mixed with them. Even as it is our sovereigns are always wearing out; we cannot send a bag of sovereigns from one part of the country to another without making them lighter, by shaking them about, and rubbing them against each other. People at the bank weigh them and pick out the light ones, and these are melted down again. Since we are obliged to use copper or silver with gold, this mixture is not worth so much as **pure** gold. In buying anything made of gold, we ought to ask how much pure gold there is in the mixture.

Another way of making the gold go further, is to **plate** or **gild** articles with it, putting only a little on the outside of the article, just as we do in silver-plated forks and spoons.

V. Love of Gold.—We find the people of nearly all countries of the world have made use of gold at all times for **ornaments.** This is because it is so **bright** and **beautiful** to look at. But this love of gold sometimes becomes a bad thing. For gold man has sold his brother man as a slave; and has even slain his fellows; while others will lie, cheat, and rob, to get the "**precious metal**", as it is called. Sometimes people get so fond of gold that they become **misers.** The word "**miser**" means a **wretched** person; and these people are very wretched indeed, for they live only for gold; and having got this, they often fear to spend it even on food and other necessary things like that.

Obverse. Reverse.

A Sovereign.

19. NOTES OF LESSONS—GOLD.

Apparatus.—Bronze, silver, and gold coins; gold-leaf, gold thread, a piece of copper.

Matter.	Method.
I. Introduction— Gold is known by its *colour*, *lustre*, and *weight*. It is used for making coins and jewellery.	I. Show children a penny, shilling, sovereign (or half-sovereign). Ask what these *are*, and for what *used*, and of what *made*.

NOTES OF LESSONS—GOLD—*Continued.*

Matter.	Method.
II. Properties— (*A*) *As drawn from the children themselves.* (*From their own observation.*) (*a*) *Colour.*—Gold is a pale red, and the only pure metal that is so. (Brass is a mixture (or "alloy") of copper, tin, etc.) (*b*) *Weight.*—The heaviest of nearly all the metals. There is one other metal that is heavier, but it is not very common, and you will not have seen it. So gold is the heaviest metal that you know. (*c*) *Soft.*—The gold coin does not keep its edges or faces so unworn as bronze or silver coins. Gold is so *soft* that it has to be mixed with copper or silver to make it harder for wear. Even then half-sovereigns soon become lighter by use.	II. (*A*) Tell the class that teacher is first going to find out what the children notice for themselves in the half-sovereign. (*a*) Compare with piece of yellow silk thread or fabric, yolk of egg, primrose, and amber. Show a piece of brass. (*b*) *Weigh* on a letter balance a sovereign against silver coins (shillings, sixpences, three-penny-pieces, etc.). Show also that a sovereign is not much larger, but very much *heavier* than a shilling. (*c*) Show a worn half-sovereign, which has become thinner and smaller by wear. Contrast with a shilling and penny of the same date of coinage (but the latter probably has been much more used). Borrow a worn wedding ring for the same purpose.
III. Properties; less Obvious— (*B*) *Taught by the teacher.* (*a*) It can be *beaten* out into thin leaves (*malleable*). Hundreds of these leaves made into a book would not be nearly so thick as a book made of paper. These leaves can be used to gild picture frames, and to make the *gilt edges* of books. (*b*) It can be *drawn* out into fine wire (*ductile*). Some things can be hammered or rolled out, but not drawn out. Dough can be rolled into very thin paste for pastry, but it would not hang together in long strips. (*c*) It does not easily *rust.* Gold ornaments more than 2000 years old have been dug out of tombs and graves; while the iron ornaments or weapons found with them have rusted away. This is one reason why it is suited for jewellery, etc., and why all nations, even savages, like gold ornaments.	III. (*B*) Now tell the class that there are some other things about gold which they cannot find out for themselves, and which teacher will tell. (*a*) Show a bit of gold-leaf ("gold-beaters' skin") and lead-foil. Show the lightness of these in letter scales. Weigh gold-leaf against an equal sized piece of paper, to show how thin it must be, since it is so very heavy. (*b*) Show a piece of gold *wire* and gold thread. Show the lightness of these in letter scales; sew with both, as with a cotton thread, and compare with fine steel and copper wire. (*c*) Contrast *brightness* of sovereign, chain, or other gold ornament, with *dulness* of lead, rusted iron, and tarnished zinc, or copper. Point out that the *colour* also is attractive. It is brighter than copper or silver. Ask class why, then, everybody does not use it for ornament (It is too dear.)

NOTES OF LESSONS—GOLD—*Continued.*

Matter.	Method.
IV. Mixtures (Alloys) of Gold— These are used to harden it. If mixed with *silver* the mixture is paler than if mixed with *copper*. So some sovereigns (Australian), with silver in them, look paler in colour than others (English), with copper instead.	IV. Because of its softness it wears away so soon that it must be *hardened* for use by mixing it with harder metals, silver, copper, etc. Nothing is made of pure gold. Refer to cheap (and eventually dear) jewellery in this connection, as having very little real gold in it.
V. How and where got— (*a*) Found *mixed* with copper and silver in the rocks of the crust of the earth. Very few metals are found in the earth pure; most are mixtures with others, or with earthy matters. These mixtures are called *ores*. (*b*) Found *pure* in *lumps* ("*nuggets*"), and grains ("*dust*") in sand of rivers, or where rivers have once been. The river wears away the rocks containing it. The gold is heavier than what the rocks are made of, so the gold grains sink to the bottom, whilst the sand, mud, etc., are carried further. Almost every country has, or has had, rocks with gold in them. Some countries have none now, as men have found all the gold and used it up. New countries, therefore, are the gold-producing countries at the present day; but the old countries used to have as much gold in them in their day as the new ones have now.	V. (*a*) Just as man can mix and melt these metals together, so they have been mixed and melted together in the *earth* deep down where it is hot enough for this to have been done. Tell the class that the earth is very hot inside. (*b*) Give a word picture of "*diggers*" digging into "*pockets*" in ancient river beds, and washing in "*cradles*" the gold from the sand and mud, with which it is mixed. Say a few words also about crushing quartz reefs for the same purpose, after that the gold on the top of the ground has been all found. Explain that we do not get much where the countries have many people, such as in England. It is where there are only a few people that we get most gold. The Jews knew of gold, for it is often spoken of in the Bible, and this is one of the oldest books we have.
VI. Uses— (*a*) For *coins* in all times and all countries. (*b*) *Jewellery*, found in the tombs of the oldest people, and in use among all except the most savage peoples at the present time. (*c*) For *gilding* picture frames, edges of books, lettering in bookbinding, covering other and cheaper metals, and for ornaments. (*d*) For *gold thread* and *gold lace*, for caps for officers, captains of ships, etc. The gold thread was used more in "cloth of gold" formerly than now.	VI. (*a*) What *coins* are partly made of gold? (Sovereign, etc.) (*b*) Ask for the names of different articles of jewellery. (Rings, watches, brooches, etc.) (*c*) Show gold-leaf, book with *gilt* edges, etc. Refer to sign-writing, etc., with gold-leaf covering the letters, etc., and to *gilding* of vessels. (*d*) Explain use of these, and show some *gold thread* if possible; if not, a bit of Indian curtain with some metal threads in it will do instead.

20. IRON.

SPECIAL INFORMATION FOR THE TEACHER.

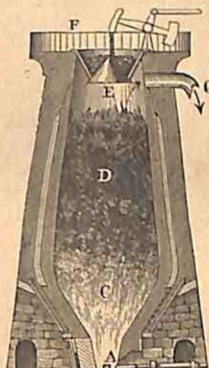
I. What Iron is.—Iron is one of the metals, and like most of these (except gold) is chiefly found in ores. Like other ores, also, that of iron is mixed or combined with various other ingredients, but the most important compounds are the oxides and carbonates of iron.

Among the commonest or most important iron-ores are—

(*a*) Red Hæmatite
(*b*) Brown Hæmatite } containing from 60–70 p.c. of pure iron.
(*c*) Magnetic iron-ore, from Scandinavia, etc.
(*d*) Clay-band iron-stone, mixed with clay.
(*e*) Black-band iron-stone, associated with coal.

Iron-ore is the most widely distributed, and, from the useful properties of the metal in it, the most valuable of all the metallic ores.

II. Long Use.—The malleable property of iron in one of its forms (wrought iron) makes it the most useful of metals; and hence it has been worked from very ancient times; and is still so in even semi-civilized tribes at the present time, for making primitive weapons of war, and of the chase, as spears, arrowheads, etc.



Section of Blast-Furnace.

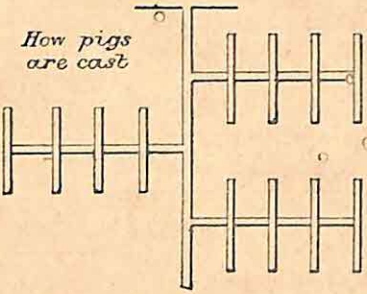
A, The place where the blast of air is introduced; B, the hearth, built of very hard stone; C, the place where the heat is most intense; D, the unconsumed fuel in the cone; E, a conical cover to furnace to keep in the gases, which are thus made to pass through pipe G, to be used as fuel to assist to heat the furnace; F, gallery to enable men to feed the furnace.

Malleable iron was thus known thousands of years before cast iron was produced, the latter dating back only 350 years. This was because the red or brown hæmatite could be "reduced", or separated from its impurities, in simple charcoal wind-furnaces.

III. Smelting.—At first wood was employed in England for smelting the ore in iron furnaces, until about 1733, when coke was first used for this purpose in blast furnaces. At the present time as much as 2,000 tons of melted metal can be thus produced weekly from a single furnace.

The impurities in iron ore are always either carbon, or a gaseous combination of carbon and oxygen, known as carbon monoxide (CO).

The metal left after reduction of the ore always contains small but very important proportions of several ingredients, specially manganese, silicon, sulphur, phosphorus, and carbon, the effects of which on the nature and properties of the iron, are not at all to be measured by their small relative proportions. In other words, pure iron is mostly rare, and does not exist commercially.



Before the ore is smelted, it is calcined, or roasted in a kiln, to drive off the water and other volatile matters.

In smelting proper, the kind of fuel employed, the temperature, and the substances to be mixed with the ore to produce a proper "slag", largely depend on the kind of ore made use of.

IV. Wrought Iron.—This, unlike cast iron, is malleable. Some of the impurities left in the pig iron are worked out in the making of it. This is effected in the puddling, or purifying out by oxidation and heated gases of the sulphur, phosphorus, etc., which make the pig iron brittle.

The steam-hammer and "puddling rolls" press the iron and squeeze out any slag in it. The metal is next reheated and passed through the rolling mill, after which it can be hammered and bent without breaking.

V. Properties of Iron.—(*a*) **Oxidizing.**—One of the most obvious of these is its rusting on exposure to damp: in perfectly dry air it does not rust. Rusting is really a slow combination that takes place between the iron and the oxygen of the air (or water), which gives us an oxide of iron. This rusting process penetrates inwards until the metal may be corroded right through.

Of course a coat of paint or other protective covering that will keep out the air and damp will check this process.

Iron will also oxidize when heated to redness, giving us black scales of another oxide of iron, as seen around the blacksmith's anvil, and called "hammer-scale" or "hammer-slag".

(*b*) It is malleable in the form of wrought iron, but not so in cast iron. In this malleable state it is most useful for constructive purposes where there are great strains and stresses, as in bridges, girders, etc., and also for ironclads.

(*c*) It is tenacious, resisting an immense breaking strain, which

fits it for making girders, lattice work, pillars, etc., as also in the construction of buildings, ships, etc.

(*d*) It is so **ductile** that it can be drawn out as fine as hair, the wire being very strong in proportion to its diameter.

VI. Steel.—This is iron combined with small quantities of **carbon**, which alters pig iron so that it can be **forged** and **hardened** when plunged into cold water, etc. It is of very various degrees of hardness and strength, the best being **tool-steel**, used for making cutlery or edged tools, such as chisels, knife-blades, razors, etc.

Next below this is **shear-steel**, used to make rougher tools, such as pick-axes, etc.

To harden steel it is heated to a red glow and then suddenly cooled. In heating it, the **colour** changes with the degree of **heat** from **pale straw yellow**, through **light purple** and **dark blue**, to red and **white**. The **hardening** effect increases with the **suddenness** of the cooling.

Among the most important **articles** made from steel are the following:—Engraving, planing, and cutting tools; drills, punches, dies, axes, adzes, saws, screw-drivers, files, and springs.

Of course tool-steel is dearer than cast, or wrought iron, as it has had to pass through more processes in its manufacture.

21. NOTES OF LESSONS—IRON.

Apparatus.—Specimens of iron ores, cast and wrought iron, steel, slag, and small articles made of iron (nails, etc.).

Matter.	Method.
I. Introduction—	
Metals.—Their common characteristics as distinguished from animals and vegetables. (*Vide infra.*)	I. Show the class specimens of the commoner metals (iron, lead, silver, and copper), and ask them for the names of these.
(*a*) *Heavy*, as in iron, gold, lead, silver, etc.	(*a*) Weigh any of these metals against wood, paper, etc.
(*b*) *Hard*, as in iron, steel, and silver.	(*b*) Let children try to scratch or indent any one of these.
(*c*) *Bright*, as in gold and silver.	(*c*) Place in contrast against the metals a bit of rock.
(*d*) Can often be *hammered* out (except cast iron) into sheets or plates.	(*d*) Show to class a plate of copper or wrought iron, as in a good fender with flat top, etc.
(*e*) Can mostly be *drawn* out (except lead) into wire.	(*e*) Show class gold thread, and iron and copper wire.
(*f*) Can be *melted* in a very hot furnace.	(*f*) Melt before the class a little lead in the bowl of a pipe.
(*g*) *Dug* out of earth, from mines; or they are on the surface of the ground.	(*g*) Show a picture of a silver mine, or of a quartz reef bearing gold in it.

NOTES OF LESSONS—IRON—*Continued.*

Matter.	Method.
II. Properties of Iron— *As drawn from the class. (From their own observation.)* (*a*) *Heavy*, so it is used to make weights for scales. (*b*) *Hard.* It is the hardest of the ordinary metals (silver, gold, and lead). It is this hardness, its cheapness, and its being easily hammered out, which make iron the most *useful* of all metals. (*c*) *Bright*, if kept dry; grey-white in colour. (*d*) *Will rust* if exposed to air and damp. Iron railings, bridges, etc., are hence painted to keep out the wet and the action of the air. Most metals, except gold, also rust when left in the air, or in the rain, as is seen in the green colour on copper, etc.	II. Tell the class that they are to point out about iron all that they can *see* from the specimens shown, or known. (*a*) Ask a child to lift the fender, to balance a poker, etc. (*b*) Enquire why we use an iron coal hammer to break coal and to drive in nails. Why not use one made of glass? (The iron is "hard" (tenacious), the glass brittle.) Hammer a bit of lead and of iron, to show the difference in their malleability. (*c*), (*d*) Contrast a rusty iron lock, or a bit of scrap iron, with a bright poker. Ask for the differences between the two. Then point out the different treatment each has had, and so establish *cause* and *effect* in the matter. One has been left out in the *wet*, the other not so. One has been exposed to the air, the other kept polished from time to time.
III. How and where got— Found mixed with earth, dirt, and with other metals. The mixtures are called "*ores*", which have to be dug out of the ground. Some are near the surface, others deep down. Iron is often found near coal. This is a great advantage for *smelting* purposes, as it saves the carriage of coal, which is expensive, as coal is very heavy.	III. Show specimens of as many iron ores as possible, some with *clay*, etc., mixed with them; others bright and *metallic*; others *red* and rusty; others *black* and dull. Ask the children to feel how heavy these are. Place them side by side in contrast. Show how the dirt or dross is got rid of by melting old lead in a pipe bowl, and showing the dross floating on the top.
IV. Kinds of Iron— Cast iron, wrought iron, and steel. (*a*) *Cast iron.*—Get the obvious qualities of this from the class:— (1) *Brittle.*—Like glass, not to be hammered out; contrast with lead, and compare with a biscuit. This is what makes cast iron not fit for articles that have to be knocked about, and to stand rough usage. But as cast iron can be easily run into a *mould*, it can be used to take any shape or form we like.	IV. Iron differs in its different stages of manufacture. (*a*) Show specimens: note the rough, rusty, coarse appearance and texture. (1) Break a small piece before the class. Refer to sauce-pans falling and smashing up. So it cannot be hammered out to shape, but can be *moulded* by pouring into shapes or moulds when melted. It is made into gas and water pipes, pillars for houses, stoves, railings, pots, pans, standards of desks, cheap fenders, etc.

NOTES OF LESSONS—IRON—*Continued.*

Matter.	Method.
(2) *Dull-edged*, so not fit for sharp cutting or boring instruments, such as razors, gimlets, screws, etc.	(2) Show, and try to cut with, a piece of common cast iron, such as the hoop of a barrel, a weight from a pair of scales, etc.
(3) *Easily moulded.*—When it is run melted into moulds or shapes it fills up these, and takes the "impression" or marks of ornamentation, etc.	(3) Show this in school firegrate, with letters of maker's name sharply defined in the casting.
(*b*) *Wrought iron.*—This is *worked* iron, or cast iron worked about in a molten state. After this it is *not brittle*, and can be *hammered*. This is then used for articles that can be beaten out, not moulded, into shape.	(*b*) Show specimen as poker, key, lock, or chain. Strike these a moderately hard blow, to show that they are not *brittle*. Refer to the blacksmith in his shop shaping on the anvil horseshoes, etc., out of bar iron.
(*c*) *Steel.*—This is *brighter* than (*a*), and (*b*); and *finer* in texture. It is also *harder*, and so is used for axles of railway carriages, etc. It will also take a finer *edge* when ground down, as in razors, knives, forks, etc.	(*c*) Show bright knitting and sewing needles, scissors, razor, knife, and fork. Contrast these with articles in (*a*) and (*b*) for, (1) Brightness; (2) Fineness of texture (with consequent *smoothness* and *lustre*).
V. How Made— (1) *Cast iron and steel.*	V. Tell class that each kind has to be made, or *manufactured*.
(1) *Cast iron.* (*A*) *Roasting.*—This is done direct from the ore, or "*ironstone*". The ore has much *water* in it, as it comes from damp ground.	(*A*) Illustrate by bonfire in garden baking some of the earth beneath and making it dry; or by burning damp clay in the fire and making it dry.
(*a*) This water is driven off by "*roasting*" the broken ore, mixed with coal, and set on fire in large heaps; or,	(*a*) Illustrate by what happens to a loaf baked in the oven. The water in the dough mostly disappears; the bread is much drier than the dough.
(*b*) It is "*baked*" in *kilns*. The heat also drives off any brimstone (sulphur) in the ore. The iron in the ore will not burn; the brimstone does, and goes off like smoke (fumes).	(*b*) Burn a small piece of brimstone before the class. Do the same with a little powdered brimstone mixed with iron or steel filings, when the former disappears, and the latter remain.
(*B*) *Smelting.*—The roasted ores, mixed with coal and lime, are now put into a *furnace*. The whole is set on fire, and air is sent in through the mass from below. The *iron* melts, the *lime* helps it to do so more quickly. The *coal* is burnt up, and passes off as smoke, or is left as ashes. The heavy melted iron runs down to the bottom into troughs in sand, making "*sows*" and	(*B*) Write on blackboard words with and without initial *s*, as *mash, smash*; *melt, smelt.* Show class a piece of *lime.* Illustrate "blast" by action of bellows on fire. Show class some lead melted in bowl of pipe or iron spoon, with "dross" floating on top. Show class a piece of "slag"; refer to its use as *road-metal.* Let class see that it sinks in water, but swims on melted lead. Point out reason for this

NOTES OF LESSONS—IRON—*Continued.*

Matter.	Method.
"*pigs*"; and the lighter part, like heavy scum, floats at the top, because it is lighter than the melted iron beneath.	different action (it is light compared with lead or iron, heavy compared with water). Draw diagram of "sows" and "pigs".
(2) *Wrought Iron and Steel.*—Wrought iron is made from cast iron by melting the latter in a furnace, to burn out from it something which makes it *brittle.* It can then be *hammered* out into shapes without breaking. In the same way heating wrought iron does something to it which turns it into *steel.*	(2) Point out to class that when lead is first melted *all* the dross does not come to the top. Melting it again and again makes it purer. [The teacher must not attempt to explain what is the difference in *constitution* between cast iron, wrought iron, and steel, as this is too difficult for young children to understand.]

22. NOTES OF LESSONS—COPPER.

Apparatus.—Copper turnings and wire, old copper coin, bronze coin, pieces of copper ore.

Matter.	Method.
I. Introduction— From the general qualities of metals we see that copper has several of these: it is *heavy, bright,* etc. (*Vide* p. 45). Copper-ore, if placed alongside lead-ore, shows different colours. Some copper-ores are *green,* others *blue.* Copper is the metal which, in the form of bronze, is used to make our cheapest, commonest, and most used *coins,* or money.	I. Show a penny, halfpenny, and farthing. Ask what these are made of. (*Bronze.*) What do we call a number of pence? ("*Coppers.*") Why? (They were formerly made of copper.) Is copper the same as bronze? (No. Bronze is partly copper, and partly tin.) Copper is a *valuable* metal, and so is used for *coins.* Compare its cost with that of coal; copper is more than a hundred times as dear as coal.
II. Where and how Obtained— Like other metals, copper is not largely found in a *pure* state; but generally mixed with sulphur, iron, and earths. The copper-ore is first *washed* to get rid of the earths, and then sent to be "*smelted*". This is done in a large *furnace.* The ore is placed in a large tank, and *roasted,* (made red-hot), to burn out the sulphur. This first furnace is an open one, to let the *sulphur* "*fumes*", or "*smoke*", escape. This work is very unhealthy for the smelters, as sulphur is very suffocating when burnt.	II. Show piece of copper-*ore,* and ask class what it is. Class will not be able to tell this, as the blue or green colour is so unlike pure copper. Why is the copper washed? (To clean the earth from it.) Write the words "*melt*" and "*smelt*" on the board: and give other words of like formation, as *mash, smash.* Light a sulphur, or brimstone match; and ask class to notice the unpleasant *smell.* Tell class that the sulphur fumes are poisonous, and *suffocating.*

NOTES OF LESSONS—COPPER—*Continued.*

Matter.	Method.
The ore is melted several times to get rid of other kinds of "*dross*". The dross floats on the top, and is now and then skimmed off. When the *pure* copper is left behind, a tap at the bottom of the furnace is opened. The melted copper runs into grooves dug in the ground, as in smelting iron. These make the copper take the shape of long *bars*.	What is "*dross*" made of? (The dirt, etc., in the ore.) Why does it float on the surface? (Lighter than the copper.) Illustrate by *cork* and *coin* floating and sinking in water; and by reference to the "*slag*" of the iron furnace. Make a drawing of the furnace on the black-board; and show the position of the *tap*. Explain that when cooled the bars are returned, to be made into different articles, as in the similar cases of iron articles made out of cast and wrought iron.
III. Description and Properties— (*a*) *Colour* reddish-brown. (*b*) *Bright* when polished. (*c*) It is a *poisonous* metal. (*d*) It can easily be *hammered* out into thin leaves, called "Dutch-metal", used instead of gold for cheap toys, picture-frames, and paper-hangings. (*e*) It can be *drawn* out into fine wire (*ductile*). (*f*) It is very *tough*, yet easily *bent*. (*g*) If struck, it gives out loud *bell-like sounds*. (*h*) It has a *disagreeable smell* when heated. (*i*) It has also a *nasty taste*, and is hurtful if put into the mouth.	III. (*a*)-(*c*) Ask children for *colours*, and other properties, to be derived by themselves as far as possible from the specimens. (*d*) Show a thin plate of copper to illustrate its *malleability*, and compare it with gold-leaf. (*e*), (*f*) Show copper wire to prove that the metal is *ductile*; bend piece of copper wire to show it is *tough*, and does not very easily break. (*g*) Strike a plate of copper, for class to note its *sound*. Show a tarnished piece of copper (with *verdigris* on it), and tell class that some people have been poisoned from dirty copper cooking vessels.
IV. Uses— Mixed with other metals, it forms (*a*) *Bronze*, which is made of copper and tin. (*b*) *Brass* is made of copper and zinc (twice as much copper as zinc). (*c*) *Bell-metal* is made of three-quarters copper, and one-quarter tin; and is used for making *bells*. (*d*) It is mixed with *gold* in making sovereigns and half-sovereigns, to harden the *gold*; one pennyworth out of every shilling in the sovereign is copper; and elevenpence worth gold. (*e*) It is used by itself for kettles, sauce-pans, stew-pans, scuttles, and other *domestic* articles.	IV. (*a*)-(*c*) Show a *penny*, and ask class of what it is made (copper and tin). Why do we use tin for this? (To harden the copper, as the coins are to stand much wear.) Show piece of *brass*; let class note the difference in colour between it and copper. (It is lighter.) Ring a brass *bell* to illustrate the sound of copper alloys. (*d*) Why is copper mixed with the gold in sovereigns, etc.? (Because the coins have a great deal of rubbing, which would wear them away soon, as gold is very soft.) (*e*) Tell class that copper cooking vessels should be lined with tin, or kept very clean.

NOTES OF LESSONS—COPPER—*Continued.*

Matter.	Method.
(*f*) It is also used for *telegraph* wires, and *lightning conductors*, and to cover the bottoms of *ships*, to keep "shell-fish", etc., from growing to the ship, and making it go slowly in the water.	(*f*) Show a piece of *copper wire*. Refer to nearest lightning conductor. Draw a picture of a "barnacle" (without naming it), and of a ship's bottom covered with these below water-mark.

23. NOTES OF LESSONS—LEAD.

Apparatus.—Lead-ore, piece of sheet-lead, lead-piping, white-lead, and previously mentioned metals; pipe-bowl, toy lead-spoons, etc.

Matter.	Method.
I. Introduction— Again refer to general characteristics of metals to show that lead agrees with these in being *heavy*, *dug out of earth*, etc.; but differs from them in not being easily drawn out (*not ductile*).	I. Make these *comparisons* and *contrasts* through the children observing the actual specimens already used in previous lessons, and comparing and contrasting them with the specimens used in the present lesson.
II. Where and how Obtained— Show a piece of *dulled*, and of *bright* lead; *dull*, because of contact with air (rusty); *bright*, when cut with a knife. Lead is a *metal*, and is very *heavy*. It is also a *mineral*, being obtained from *mines*.	II. Cut a piece of lead to show its *bright shining* appearance, and show a bit that has been exposed to the air. Let the children feel the *weight* of a bit of lead. Ask for some other heavy metal.
It is generally mixed with *sulphur*.	Show a piece of *brimstone*, or a sulphur match.
The lead-ore runs underground in "*lodes*" or "*veins*". A pit, or well, is dug until the "vein" is reached, when the lead-ore is dug out, and sent to the pit's mouth.	Draw a section of a lead mine on the blackboard, and explain the meaning of "lodes" and "veins", by referring to the veins on the back of the hand.
The lead is obtained from the ore by *melting*. The *sulphur* is first got rid of by *roasting* the ore in an open furnace. The sulphur is turned into a gas, and escapes; leaving behind the lead mixed with earth.	Show a piece of lead-ore. Point out the earth, rock, etc., in it. Burn a piece of sulphur to give off *poisonous* "*fumes*". Put some lead and sulphur in a pipe-bowl and heat them. The sulphur goes off, and lead and dross remain; the latter, floating on the top of the metal. Why does the *dross* float? (*Lighter* than the lead.)
The ore is now heated in another furnace to melt out the pure lead from the earth. The former then runs into *troughs* or *grooves* to cool. It is now called "*pig lead*".	Draw a rough sketch of the furnace and troughs on the blackboard. Contrast the pure lead with the lead-ore.

NOTES OF LESSONS—LEAD—*Continued.*

Matter.	Method.
III. Properties— (*a*) Lead can be used in the same way as "black-lead" for *writing*, only less perfectly.	III. (*a*) Rub lead on a piece of paper to show the *streak* made. Compare this with that made by a "black-lead" pencil.
(*b*) It is not very "*tough*" nor *flexible*, breaking after moderate bending. Hence it is not made into wire.	(*b*) Take a thin length of lead, *twist* and *pull it*, to show its want of these properties of *toughness* and *flexibility*.
(*c*) It can be *hammered* out, but not *drawn* into wire, not being a good metal for the latter purpose. Copper and gold are both better.	(*c*) Compare with glass, sealing-wax, etc. *Hammer* out lead. Show piece of copper or gold wire, contrast with a piece of home-made lead-wire.
(*d*) It is a very *poisonous* metal, and men who work in lead mines, or deal with lead in any way, have to be very careful. Some paints have lead in them.	(*d*) What are men who work in lead called? (Miners and plumbers.) Note frequency of lead-poisoning in plumbers and painters.
(*e*) In colour it is *bluish-white*.	(*e*) Compare with silver, show a lead and a silver spoon.
IV. Uses— (*a*) *Sheet-lead* is made by flattening out pig-lead between steel rollers; this is used for *covering roofs* of houses, *lining* rain-water cisterns, etc. The Chinese line tea-chests with thin sheets of it. Boots, etc., exported long distances across sea are sent in boxes lined with "lead foil".	IV. (*a*) Show piece of *sheet-lead*, and tell how made from pig-lead. By hammering. Hammer out a piece before the class. Show how lead is used to make gutters, etc., on roofs. Why do the Chinese line tea chests with lead? (To keep the tea dry, and to retain the scent of the tea.) Show pieces of this "lead-paper".
(*b*) The most important use of lead is for gas and water-pipes (as thick lead is easily *bent*, *melted*, *hammered*, etc.).	(*b*) Show by bending piece of pipe how easily any awkward angle, etc., can be fitted with piping. Refer to lead cistern, taps, etc., at home.
(*c*) For making *shot* and *bullets*, this use being due to its weight. (*d*) Mixed with *antimony*, it is used for *type*, or letters for printing.	(*c*) and (*d*) Show *type-letter*, *bullet*, and *shot*, and tell how used respectively.
(*e*) It does not rapidly rust like iron, so is used in the open air to cover roofs, etc.	(*e*) Ask class for the covering of a neighbouring church, top of bay window to house, etc.
(*f*) "*White-lead*" is used by *painters*, and is made out of lead by pouring something sour like vinegar on the metal. It is, as its name shows, pure white.	(*f*) Show *some white-lead* and some *paint* made from it. Tell children that black-lead is very different, it is not lead at all, as white-lead is.

24. NOTES OF LESSONS—METALS IN GENERAL.

Apparatus.—Specimens of as many metals and their ores as can be obtained.

Matter.	Method.
I. Introduction— By taking a number of *different metals,* such as zinc, iron, gold, tin, copper, lead, etc., we get to know in what ways they *agree,* and in what they are different, or *disagree,* or differ from each other.	I. Tell the class that when we want to know about anything there are always two things to think of: (1) To find out what the thing is *like*; and, (2) In what way it is *different* from other things belonging to the same group.
II. Properties— These metals all *shine* and look *bright,* and are *heavy* (all sinking in water), and are *solid.* If we melt a piece of lead in the bowl of a tobacco pipe we see that some metals will *melt.*	II. Ask the class to say in what different ways the specimens, or any two or three of them, are *like* each other, and write these several *agreements* on the black-board.
(*a*) A piece of new tin, a bit of looking-glass with quicksilver at the back, and a new penny, shilling, etc., are *bright,* and give back or reflect *light* shining on them.	(*a*) Show a bit of bright tin and looking-glass, and *reflect* the sun from these, throwing the reflection across the school-room. Point out this use of tin in the *reflector* behind, or above, a lamp.
(*b*) *Some* of the metals let *heat pass* along them very easily. If a piece of *copper* wire be put partly in the fire, the end outside the fire also soon becomes hot. But if a piece of *iron* is so treated, the end outside the fire takes a longer time to get hot. So some metals let heat pass along them sooner than others. But a piece of *wood* would hardly let any heat pass along it at all.	(*b*) Illustrate this by the *wooden* handle to the *metal* coffee pot, and by the *cloth* iron-holder used with a *flat-iron* in ironing; and put a few grains of gunpowder or a little bit of phosphorus or wax on the part of the poker farthest from the fire, to show the passage of heat along it. Do the same with a piece of wood to show what a much longer time it takes for the heat to pass along this.
(*c*) *Some* of the metals can be *drawn* out into very fine *wire,* as gold, copper, and steel. These thin wires will also bear a great *weight* before they break.	(*c*) *Suspend* a flat-iron, etc., from a thin wire of steel or copper. Show the class some gold thread used for officers' caps, etc.
(*d*) *Some,* as gold, copper, and silver, can be beaten or *hammered* out, into very thin plates or sheets, as is seen in a piece of gold-leaf used for gilding frames, etc.	(*d*) *Hammer* out on a stone, or on a flat-iron, a piece of copper wire before the class. Refer to copper plates used on the bottom of ships, and to copper kettles, etc.
(*e*) *Some,* as copper, can be used for telegraph wires and lightning conductors.	(*e*) Show a piece of *copper electric wire,* and, if possible, a section of a *telegraph cable.*
(*f*) We *cannot see* through metals, even though they be very thin; they are not *transparent* (but opaque).	(*f*) Put a bit of *gold-leaf* over the letters in a book, and ask a boy to read the book through this.

NOTES OF LESSONS—METALS IN GENERAL—*Continued.*

Matter.	Method.
(*g*) The metals can be melted from solids into liquids by means of heat; this often first turns them red-hot, then white-hot, as in the case of iron.	(*g*) Melt a piece of *lead* in the fire, and in the bowl of a pipe. Tell class that the same thing can be done with iron, etc., but that it takes a much greater heat to do so.
(*h*) Most metals are very heavy; but some are heavier than others. The heaviest in our list is gold.	(*h*) Show *brass* and *iron weights* used with scales, because of their being heavy. Weigh on letter scales a sovereign and a shilling.
(*i*) Metals are found in the *earth*, and generally in *rocks*, so that men called "*miners*" have to dig the ores out, or *blast* the rocks with gunpowder, etc. Then others melt the metal out of the ores. Gold is found pure in river beds, etc., where the water has worn the rocks away and so let the gold drop in very small grains. Different metals are found in different parts of the earth. Iron is found in England, gold and silver in other countries.	(*i*) Show all the specimens of *ores* that there are in the school. Explain to the class that the iron of our own country is partly what makes England so rich, as it is the *cheapest* and the most *useful* of all metals for making machines with which to carry on all our other trades (cotton, wool, etc.). Refer back to lesson on gold for this item. Tell class that savages do not know much about metal-ores; so there is plenty of iron-ore in their countries not yet dug out.
III. Uses— Metals are *used* for many different things. Some of them specially are used for making machines, guns, cannons, anchors, bicycles, drain-pipes, water-pipes, kettles, boilers, etc. Others and the richer metals, specially gold and silver, for jewellery, watches, clocks, etc. These used depend, in the *first* list, on their being *hard*, easily *melted*, taking a cutting *edge*, bearing a great weight or *strain*. And in the *second* list, on their *brightness*, *colour*, and *fineness*.	III. Refer back to the *differences* already pointed out in the various metals. This shows that they must be *used* in different ways. Thus, we could not use *lead* for *wire*, nor to make *sheets* nor plates. Nor could we use *gold* for making *ships*, because there would not be enough of it for this purpose, besides other reasons against it. So the *cheap* metals are used for *useful* articles, and the *dear* ones for *ornaments* and *pretty* things.
IV. "Precious Metals"— These are those which are the least common, such as *gold* and *silver*. They are, therefore, very *dear*; for what is very common, such as pebbles, clay, etc., will not fetch a great price. These "*precious*" *metals* are used for making *money* and *jewellery*, such as watches, chains, rings, etc. They are also of beautiful *colour* and *brightness*, and so are used to make vessels, and to *gild* and	IV. Explain that "*precious*" means very scarce and "dear", but that this quality is not so good as to be very "*useful*". So these "precious metals" are used for things of which we do not want very many. Thus, a little *money* is all most of us want to carry on trade with. What a man earns in a week can be easily carried in silver or gold in his waistcoat pocket. But he could not carry all the iron, the

NOTES OF LESSONS—METALS IN GENERAL—*Continued.*

Matter.	Method.
plate the outsides and insides of vessels, ornaments, etc. (*a*) *Gold* is *yellow*; very *heavy*; very *soft*; does not soon *tarnish* or take rust; can be *beaten* out into the thinnest sheets, and *drawn* out into the finest wire. It is found in lumps (*nuggets*) and in fine grains in sand washed down from rocks by rivers. (*b*) *Silver* has many properties like those of gold; but is *white*, *not* so heavy, and *harder*. It is also much *cheaper* because more common. It is found in rocks, and specially in silver mines.	price or value of which he could earn in a week. (*a*) Show a half-sovereign and a sixpence, and get from the class the ways in which these are *alike* and *different*. Then contrast the *common* property of both (*dearness*), with the comparative *cheapness* of all the other metals. Refer back to the lessons on gold previously given. (*b*) Get these from the children by showing a silver coin, silver spoon, silver watch, etc. Refer to the alloying of gold with silver the latter being *harder* than the former, as given before.

25. NOTES OF LESSONS—METALS AND NON-METALS.

Apparatus.—Iron (cast and wrought), iron wire, copper, copper wire, a knitting needle, quicksilver, stone, clay, chalk, lead, and sulphur.

Matter.	Method.
I. Sorting— In another lesson we shall divide solid substances into *hard* and *soft* ones. Solids can be also separated into two other lots or classes:— (1) Those that are *heavy*, *bright* and *shining*; and (2) Those that are *not* heavy, bright nor shining. For these we have two different names, namely:—	I. Ask for the names of the different specimens shown, in the list in the "Apparatus". Let a boy *separate* these articles into the two groups as here mentioned, the teacher correcting where necessary. Leave out at first the quicksilver, then ask which group this ought to be placed in (*bright* and *heavy*); and get from the class that it is a *liquid*, while all the others are solids.
II. Metals and Non-Metals— (*a*) The substances of one lot are *bright* and *shining*, of the other *dull*. This first group includes all in list above, except stone, clay, chalk, and sulphur.	II. (*a*) Ask children to *contrast* members of the two groups in this respect, illustrating the two groups by the items mentioned in the "Apparatus".
(*b*) The *weight* of those in the first lot is greater generally than that of the other.	(*b*) Let children feel difference in *weight* of lead and chalk, and of quicksilver and sulphur.
(*c*) Those of this first group will often not *break* if hammered (not *brittle*); those of the other will often do so.	(*c*) *Hammer* the iron, lead, etc., and also a piece of chalk, stone, etc. Note what happens in each case. (The one *breaks*, the other does not.)

NOTES OF LESSONS—METALS AND NON-METALS—*Continued.*

Matter.	Method.
(*d*). *Heat* will easily pass along those of the first group; especially along the copper and steel knitting needle; but not so readily in the other, and hardly at all along the clay and the chalk. So it would take a longer time to boil water in a clay pipkin than in an iron sauce-pan.	(*d*) *Heat* one end of a knitting needle in the fire or gas flame, and let a boy feel the other end after a short time—it is *warm*. Do the same with a chalk crayon held in the gas flame; it remains almost cold.
(*e*) The first lot can be often pulled out into long threads (*wires*), while the other lot (the second) cannot.	(*e*) Show piece of copper wire, and try to *pull out* clay, sulphur, stone, etc.
(*f*) One lot can be turned from the *solid* to the *liquid* state by heat, while the others would mostly crumble or burn away. Chalk when burnt does not melt in the fierce heat of the furnace, but turns into lime, just as coal, when burnt, makes ashes. The first lot, with the former qualities, we call "*metals*"; the other "*non-metals*", or those that are not metals.	(*f*) Burn some of the sulphur in the fire. Then heat another small piece of it with red-hot copper wire; the sulphur burns, the copper does not so. *Melt* the lead in an iron spoon or pipe bowl; try to do the same with chalk or clay. Explain that "*non*" means *not*, and that *non-metals* are, therefore, those substances which are *not* "*metals*".
All *minerals* must be either one or the other of these, but we generally keep the name minerals for the last lot, or the *non-metals*, such as coal. Both minerals and metals are dug out of the earth.	Give a number of other substances for the children to classify into metals and non-metals, according to their having, or not having, the above properties.

MINERALS.

26. COAL.

INTRODUCTORY SPECIMEN LESSON.

I. Peat.—Perhaps you have seen peat dug up out of the ground, and piled up in stacks, to be dried as "turf" for fuel. If so, you know trenches are dug in the ground; and that the peat is made up of the soil itself, and of what was once growing there in a marsh or bog. As one crop of plants grew and gave place to another, the peat was formed ever thicker and thicker. This did not rot away; but was kept from doing so by the water of the marsh or bog. So that when a long time afterwards the water was

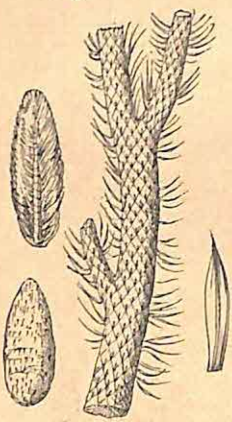
drained off by ditches, or by the ground slowly rising, peat was left there for the use of man.

II. The Peat is Covered.—You will say this subject has something to do with **coal.** Well, yes; a great deal, as you will see shortly. In the first place it is coal in its first stage; that is, **peat is coal being made.**

But some one in the class may say, "Coal is dug out of the ground, and not found on the top of it". That is mostly true. But the top, or surface, of the ground is not always still; as you think it is. Sometimes it slowly rises into hills and mountains in one part; and slowly sinks down into valleys in another. Then the part that sinks the lowest often goes down beneath the sea; and so waves wash sand, pebbles, clay, and other things over the peat, and bury it beneath them. And sometimes the rivers, too, wash mud over the peat-beds, and cover them up.

III. Coal.—There the peat may lie hid for thousands of years, until it has become **hard** with the great weight of the rocks above, and **black** with the changes that take place in it beneath the ground. Then it is turned into **coal.**

So you see that coal has been made out of plants; such as mosses, ferns, reeds, pines, and many others of which you do not know the names. And that is how it is that in digging coal out of a mine we sometimes come across, under the coal, the great **roots** of the trees in the clay in which they once grew. We also come across the **stems,** or trunks, of these trees; and even find the marks of the **leaves** still left perfect in the clay.



Coal Plants.

There was a time when there were many forests in this country, like the forests in the hot countries of the globe at the present day. Then the ferns and reeds growing here were not **small** plants, only a few feet high; but as high as the school. It is partly out of these that our coal was made; and there is nothing we have which is of so much use to us as coal.

IV. Uses of Coal.—Coal is the best **fuel**;—that is, it has the most **heat** in it, of all common kinds of fuel. If we had to burn **wood** only, think how dear it would soon be; and how dear it would make corn and other crops. For we should be obliged to leave a large part of the land to grow forests on. That would take

away from the land that grows wheat, barley, and the vegetables and fruits of the garden.

And we want coal for so many things :—

(*a*) First, to heat our houses, and cook our food.

(*b*) Secondly, to make gas from it, to give us light at night ; and

(*c*) Next, to boil water to turn it into steam. And this steam when it is shut up close, like a man in prison, tries to get out ; and in the trying, it turns our machines that make linen, cotton, silk, and other goods, and even other machines themselves.

(*d*) We also want coal to melt, or smelt, our ores. These ores are dug out of the ground ; and are mostly not pure metals, but mixed up with a lot of earth and other things which we must first get rid of, if we wish to turn them into pure metals. Among the most common ores which we have to smelt is iron, which thus uses up a very great part of our coal. Each ton of iron that is made wants very much more than its own weight of coal to make it. Think what a great deal of iron we want to make all our ships, iron houses, fences, rails, pots, forks, knives and other cutting tools.

V. Kinds of Coal.—Some coal is hard, and some is soft. Some burns in the fire, and cakes, or runs together. This is the kind of coal people mostly use in London ; it wants poking in the grate to burn well, and to make it burst into a blaze.

Other kinds of coal give very little flame or light, but a great heat, and do not want poking.

Again, some is so hard that it will not burn in a common grate, but must have a strong draught such as we can only get in furnaces and steam-ships.

VI. Where Found.—The places where coal is found are called coal-fields, only they are fields mostly beneath the ground. Here we find the coal in "beds", that is, the places where the coals lie. In digging through these beds, we pass through layers, or "seams" of coal.

The coal has to be brought up to the top through shafts, which are deep wells dug down from the top of the ground to the seams. It is up and down these that the full and empty coal-waggons are pulled up and let down by a machine.

VII. Factory Towns.—It is because we cannot drive our machines without coal, and because we cannot make goods without machines, that we now find that nearly all the large towns that make goods for us, and for other countries, are on coal-fields. These towns are built on the top of coal beds to save carrying coal to them from places farther off.

Nearly all the large towns which have been built in the last hundred years, except the seaport towns, are built on coal-fields. On some coal-fields you would find the cotton towns, where people make cotton goods. On others are the woollen towns, where they make woollen goods. On others towns where they make cutlery, that is, cutting tools. On others the places where hardware, or iron goods, such as posts, rails, iron plates, etc., are made. Others would make silk, hose, lace, pottery, and so on.

27. A COAL MINE.

INTRODUCTORY SPECIMEN LESSON.

I. Where Found.—Forests of ferns and reeds, and beds of peat once grew over large parts of England and other countries. These forests and peat beds were afterwards covered over with clay and sand, and were slowly turned into coal. They made the "coal-fields".

A "coal-mine" is that part of the "field" which is worked. A "coal-pit" is the shaft or well dug down to reach the coal. A "coal-seam" is one layer of the coal thus reached.

II. The Coal-Seams.—There are generally several seams, or layers, in a coal-field, one above the other, some thick and some thin. If they are thinner than about two feet, it does not generally pay to work them, as it costs more than the coal is worth to get it out. There are more beds almost as thin as this, than thick ones of five or six feet, or more. Some of these seams are as level as the peat beds and forests that at one time made them; they have not been lifted up from beneath, nor pushed up at one end and let down at another. These level seams are mostly very deep down under ground.

But more often the beds have been tilted up more or less; and if it were not for this, we should sometimes not be able to get at the coal because of its great depth.

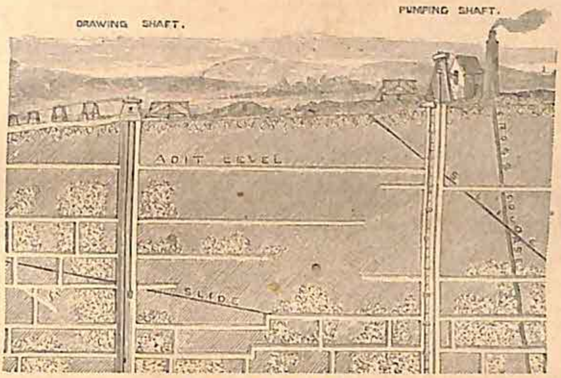
Sometimes they have been tilted up so much, or the rocks above have been so much worn away by rivers and waves, that the seams are now on the top of the ground. We can then begin to dig the coal at the surface, or work it on a slope more and more deeply, until the seam goes down so far that it will not pay any longer to follow it and get the coal out of it.

III. A Coal Mine.—Let us go down a coal mine and see what it looks like. At the top of the pit shaft there is an engine, and

this pumps out from the mine the water that runs in from underground streams. It also lets down the empty coal-waggons, "baskets", or "cages", and brings them up again full by a rope that passes over a large wheel.

We will get into one of these cages, and we had better take firm hold of the rope to which the cage is fastened. Away we go down the black hole, and the mouth of the pit above becomes smaller and smaller to look at. All is dark as we pass swiftly through the air. It is a long way down, many hundreds of feet; but here in a very short time we are at the bottom, or, rather very near the bottom. It would not do to let the cage touch the bottom, or we should be all jerked out and killed.

IV. Fresh Air.—It is quite a town under ground! There are long rows of lamps leading away down the lanes and alleys for



Section of a Coal Mine.

many miles altogether. And what a large fire they have here. This is to make a draught up the pit-shaft, and as the hot and foul air goes up one shaft, fresh pure air from the top comes down another. It is well that it does so, for there are some gases that come out of the coal which are full of danger. That is why the men here have got such strange-looking lamps. If they used a naked light, they would set fire to a gas that comes out of the coal called "fire-damp".

V. Fire-Damp.—This would explode and blow them to pieces, and the mine too. You see that the lamp is shut up. It is locked up so that the flame may not get to any fire-damp there may be in the pit. If there is a great deal of this fire-damp, the flame

in the lamp becomes very large. It will even fill all the lamp and make the wire of it red-hot; and then the fire-damp outside of the lamp would explode. So when the lamp fills with flame, the miners come up, and let this gas be got rid of before they go down to work again.

Sometimes the men get used to this danger and so grow careless and keep on with their work until the gas explodes and many are killed. Sometimes, too, they strike a light for their pipes, though this is not allowed; and then, too, the fire-damp explodes.

VI. The Carriage of Coal.—You see that there is a railway line laid down, and waggons full of coal are being drawn by horses, or boys, from the distant parts of the pit to the bottom of the shaft, to be taken to the top. There yonder are the stables for the horses, which sometimes never come out of the pits after they have been once let down.

VII. The Coal Itself.—We call the places "stalls" where the men yonder are digging out the coal. There is a headman who has charge of these, with others who work under him, or for him. Some of these are called "drawers" or haulers, for they do not dig or hew out the coal themselves, but draw it out after it is dug down, and fill the waggons with it.

Here where the seam is a good thick one, we can stand upright in the passage way from which the coal has been dug out. You see the roof is kept up either by pillars of coal, which have been left for this purpose, or by yonder beams of timber.

When the pit is worked out, the ground very often sinks down where the coal has been dug out. Then the buildings on the top sink with the ground, and fall down or crack, or are obliged to be pulled down as unsafe to live in.

VIII. Dangerous Work.—It sometimes happens that a coal mine takes fire. The pit-mouth is then shut up so that no air may get to feed the fire below. But fire will not burn without air, so the fire goes out, though sometimes a mine has been known to burn for years. Then we are obliged to send water down the pit to put out the fire. Of course the water has to be pumped out again before the pit can be worked any more, and this is a great loss to the owners.

IX. The Miners.—You see some of the men are obliged to lie on their backs and pick out the coals over their heads. This is dangerous work, as portions of the roof often fall down and kill the hewers of the coal. Sometimes, too, the miners come to old workings, where the water has collected, and then the water rushes in and drowns them.

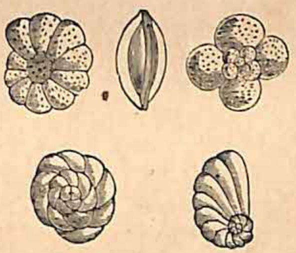
How wild and strange the miners look with their black faces, arms, and hands. The air is so close and warm, that the sweat runs down their faces, and leaves streaks as it trickles through the black dirt. And we shall want a good wash ourselves, so let us go back. Get into the cage, and the man at the bottom will give the signal to the man at the top to haul up. Ah ! now we are off, and now once more upon the pit-bank above.

28. CHALK.

INTRODUCTORY SPECIMEN LESSON.

I. What I Am.—A long time ago I was a soft mealy mud at the bottom of a deep ocean. This was so deep, indeed, that the light of day could not reach down to where I was. This sheet of soft mud was very thick ; and was spread out far and wide around me for many miles. Now I am hard and solid, very often showing myself as rounded hills, without trees, but covered with short grass.

II. My Past History.—(*a*) **Youth.** In fact, I am made up of whole and broken shells of creatures that once lived in the ocean. These have long since died, and left their shells at the bottom of the deep.


Foraminiferæ (recent).

If you take a very fine brush and rub it on a piece of common chalk like myself, some of it will cling to the brush. If this brush be then dipped into a glass of water, the fine chalk dust will fall down to the bottom of the glass. Let this settle for a few hours, and then gently pour off the clean water ; and a fine white mud will be left. If this be dried, and put under a glass to magnify it,—or to make it look larger,—it will be seen to be made up of "shells".

The creatures that carried these shells were very simple **jelly-like** animals ; but the shells they made are in many cases very beautiful. Some of them are made of **lime** ; but a few are made of **flint**.

(*b*) **Middle Age.** It is a long time ago since I was lying at the bottom of the deep. Then the bed of the ocean rose little by little. But I am told some of my family are still at the bottom of the

oceans to-day; and that many of their shells are like those of which I am made up.

(*c*) **Old Age.** What "ups and downs" we have seen in our time! I once lay several miles below the surface of the water. But you now dig me out of a chalk-hill nearly a quarter of a mile above the sea. So if we have been **low** in the world at one time, we have held our heads **high** enough above water at another.

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III. Size.—You could put millions of us into a thimble; and yet we now form hills a thousand feet high. If we are **small** taken singly, we are not to be despised on that account; for with us in the lump of chalk you manure your land, or you burn us in kilns to make **lime** for mortar. Sometimes, too, we have had such heaps of rocks piled on the top of us, and we have been pressed so hard, and so changed in other ways, that we have turned into **limestone**. With this you build your houses and bridges; and one branch of my family gives you **marble**.

IV. Flint.—I said that some of us had "shells" of flint, instead of lime. If you go to a chalk cliff, you will often find the lower part of it with large flints either in layers or in single lumps. These have been made out of my **flinty brothers**. The flint of their shells was eaten out by the hot water trickling through our bed; and cooled down again into these layers, or lumps.

But you will also find these flints on the top of the ground sometimes. All the time we have been above the sea, the rivers have been cutting out valleys. The rains, too, have washed off our soft flesh, leaving the flints as the "bones" which they could not "pick". These remained on the top of the ground, while the white, muddy streams carried off into the sea the softer chalk.

V. Where Found.—You will find us here and there all over the world. In your own country, we form the chalk hills, or **Downs**, as they are called. It is we that give you the **"white cliffs"** of old England.

You will also find us again in France, and you will have to dig your tunnel through us, if you join England to France by a railway.

VI. Fossils.—If you take a hammer and a bag, you will soon be able to chip out of a chalk hill and bring away with you some of the strange fellows that kept us company in the days long since. These are what you call "**fossils**". Many of them are like what you will find at the bottom of the sea now. But larger living forms than these lived with us in those days, such as **fishes**, and among them **sharks**, with very sharp teeth, that lived on the rest.

29. NOTES OF LESSONS—CHALK.

Apparatus.—Solid and powdered chalk; and "prepared school chalk"; whiting, oyster-shell, limestone, lime; sugar, and salt.

Matter.	Method.
I. Introduction— In a former lesson we had a mineral that was not a *metal*; in this we have another.	I. Enquire from the class the names of the various specimens shown on the table.
II. Properties— (*a*) *Colour*, creamy, or white and dull. (*b*) *Brittle*, crushing or crumbling easily under a smart blow. (*c*) It does *not* "*melt*" in water, which it at first makes white when powdered chalk is put into it, the cloudiness soon settling down as a fine white, pasty sediment.	II. (*a*) Show the same colour in limestone and in an oyster shell. (*b*) Gently tap a piece of chalk with a *hammer*, on which it will fall to pieces. (*c*) Refer to some towns, as Brighton, getting their *water supply* from rains that have passed through hundreds of feet of chalk and yet are clear. Contrast with salt and sugar (*soluble*).
(*d*) It is *easily separated* in its particles (*friable*), so that it leaves a mark on the blackboard when pressed or drawn hard over it. Because of this property it is also made into *whiting* for cleaning silver.	(*d*) Explain that it owes this useful property to its being made of very minute "shells" or coverings of marine animals too small to be seen without a microscope. Copy a few drawings of these creatures (*foraminiferæ*) on the blackboard.
(*e*) When burnt in a kiln, it becomes *lime*. Limekilns are set up in the side of a chalk hill or "chalk-pit", as in the Downs. Sometimes limestone is thus burnt in a kiln instead of chalk for making lime.	(*e*) Explain the process, and compare with that of making *charcoal*. Tell the class that the heat drives off a gas, without naming this (*carbonic acid*), and then the lime is what is left behind when the gas is gone. The lime is very brittle.
III. Uses— (*a*) The harder, larger, and coarser chalk found in some parts (the Downs) is used instead of stone for *foundations* of houses, filling in of walls in quays, etc.	III. (*a*) Show the class a bit of this hard chalk, and make them see how *close* it is. Explain that it is also very *cheap*, as the solid hills of the Downs, hundreds of feet high, are all chalk.
(*b*) Burning into *lime* for building purposes. Hence houses cost less to build near chalk hills.	(*b*) Explain, as above, the reason of the *cheapness* of lime made out of chalk.
(*c*) To spread on the land as *manure*.	(*c*) Tell the class that some plants like chalk soils.
(*d*) To make *whiting* for white-wash, etc. This keeps a house sweet and healthy too.	(*d*) Show the class a piece of whiting, and make it into "*white-wash*" before the children.
(*e*) For *writing* and *drawing*: some chalks are *coloured* for the latter purpose.	(*e*) Show some *coloured* chalks. Compare drawing "chalk" with the native lump (softer, finer, etc.).

30. NOTES OF LESSONS—CLAY AND SHALE.

Apparatus.—Red, white, green, blue, and brown clays; flakes of shale; potsherd, earthenware, flower-pot, porcelain jug; bits of tile, brick, and drain-pipe.

Matter.	Method.
I. Introduction— Besides *sandstones*, *limestones*, and granite, the *face* of the ground, and the "*crust*" underneath it, are sometimes made of *clay*. Sometimes also this forms the top of the ground for miles, and for many feet in *thickness*; whilst at other times it is found only in *thin* layers. It very often makes the tops of hills, and it also forms the valleys and beds of rivers.	Tell the class that the first kind of rock from which most of the others have been made is granite. Also tell class that the *sandstones* have been made out of a *part* of these granites, and that *another* part of them has given the stuff out of which *clays* are made. And a third part has been used up to make the stuff out of which *limestones* are built up.
II. Properties— (*a*) *Colours.*—Of *various colours*, generally red or brown. This is seen in *red* bricks, which are made out of burnt or baked clay; but there are also *white* and *blue* bricks.	II. Show the class all the specimens of clays on the table. (*a*) Ask for their various *colours*; compare and contrast these with those of sands and sandstones. In these *white* is the commonest colour, what is it here? (Brown or red.)
(*b*) When damp, clay is *soft* and *greasy* to the touch, *sticking* to the fingers, *clinging* to boots, to ploughshares, spades, shovels, hoes, etc., in the field. It seems *not* to consist of single grains like chalk and sand. But if a little be shaken in water, the dried mud is seen to be in particles as the sand was, only very much smaller.	(*b*) Contrast with sand which, when dry, runs through the fingers without sticking to them. But remind the class that *wet* sand hangs on the hands; and clay also, when quite dry, does not stick. Let the children handle some wet ordinary clay and "modelling clay" used in the Infant school. Compare with butter and cheese.
(*c*) The particles are almost too *small* for their shape to be *seen*. We do not see each singly, but the lot together, just as in a building at a distance we do not see the single bricks.	(*c*) Shake up a little clay in water. The class will see the *cloudiness* rising. *Filter* on blotting paper: even then the *single* grains are not visible until they are dried.
(*d*) *Dull.* The particles look *dull*, without any *lustre*, or appearance of gloss. They have a "*muddy*" appearance.	(*d*) *Compare* with soil (earth) and *contrast* with quartz grains, white sand, and the dust of metals (steel filings, etc.).
(*e*) *Plastic.* The particles are sticky, clinging *together* so as to be readily *moulded* into shapes; hence, partly, the great use of clay to man to make drain-pipes, tiles, bricks, etc.	(*e*) Ask class why a lump of clay does not fall to *pieces* like a handful of sand. Get from the class illustrations of this *plastic* property employed in making bricks, pottery, etc.

NOTES OF LESSONS—CLAY AND SHALE—*Continued.*

Matter.	Method.
(*f*) *Hardens with heat.* It sets hard when baked, and then does not become again 'sticky' and 'greasy'; hence also, partly, its use for making bricks, drain-pipes, etc.	(*f*) In winter bake a small piece of clay on the bar of the school *grate.* Show the class baked clay used by *builders.* Heat *sand* to show the contrast.
III. Whence derived— (*a*) *Water-carriage.* Clays are obtained, like sandstones, from the wearing down and washing away by *rivers*, rains and seas, of old *granite* rocks. But the rivers carry the clinging portion of these granites, or the clays, *right out to sea*, instead of dropping them down, as sand, near their mouths. This is because the particles are *smaller*, and therefore *lighter*, than sand, and thus do not so easily sink to the bottom.	III. Shake up in water some of the *powder* got from a granite *stone-heap*; after a slight settling of the heavier particles pour off the top clear water. Let the rest *settle*; the sediment after a few trials will give what will stand for the *clay* part of the finely powdered granite. Point out to class that as the granites are generally the oldest rocks, and the others have been made out of these old ones, the clay must once have been a part of the granite rocks. Show a piece of granite.
(*b*) *Ice-carriage.* Besides water-carriage, *ice* grinds down the granite rocks containing clay in them, and carries this clay with it as it slides as *glaciers* over the ground. Then the rivers wash away this clay when the ice melts, or the ice carries it right into the sea with it, until the *iceberg* melts and drops it down.	(*b*) Shake up some coarse sand and fine pulverized *clay* in a bottle to show that the *sand* drops *first* to the bottom, and the clay *later* on the top of it. Show class a picture of a *glacier* and call this a "*river of ice*", and explain how it slowly glides down a mountain valley, and grinds the rocks as it slides over them.
Icebergs do the same when grinding the bottoms of the seas whilst they are being carried or driven over them in shallow parts.	Show a picture of an *iceberg*, and explain it as a "*mountain of ice*" sailing in the sea like a ship, and carried by the currents or "streams in the sea".
IV. Shale— This is a clay now *hardened*, *dried*, and *pressed* together in layers, or flakes, by the weight of the rocks above. It is very common over and under beds of coal, where it is sometimes called '*underclay*' and '*overclay*'. Being clay, this shale can also be made into bricks for colliery works, etc. It is generally of a *bluish-gray* colour; laid down in *thin beds*, or layers, and when hard is somewhat like *slate*—which is a still harder kind of clay—and can be used to make a mark like a slate-pencil. Some slates are full of *mineral oil*, and this is got out to make *paraffin*.	IV. Show flakes of these shales of various *colours* and *thicknesses*, and call attention to their *dryness*, and compare with flakes of *pie-crust*. Explain that 'underclay' is a good name, as it is *clay under* the coal. In a colliery district show the *raw* shale and the *brick* made out of it. Show a specimen of shale, and explain that the *river* washed it down, and that as the river dried up it made these *layers*. Show pieces of *school* and of *roofing* slate; and compare and contrast these with the shale, asking for the *likenesses* (all three made of *clay*, all *dried*, and all *hardened*); and *differences* (the slate is much *closer* and *harder* than the shale).

31. SLATE.

FIRST INTRODUCTORY SPECIMEN LESSON.

I. What I Am.—You see me now as a piece of fine slate upon which you write; or as a coarser kind used for covering houses; but in either case I am now hard and dry. And yet a long, long time ago, I was wet and soft, a part of a mud bottom to a sea. Some of my relations at the time were a part of a mud-bank, baked by the sun at low tide; just such a mud-bank as you will now find along the coasts of England in many parts.

In my present state I am found in Wales, and many of the famous Welsh mountains are entirely made out of me. As I am so hard, the rains and frosts have little effect in eating me away. So I stand out in bold peaks, cliffs, and crags. Between my joints the ferns and other wild plants grow; and down my cracks the streams run along. My most useful property is that of "cleaving", or splitting asunder, into thin plates. That is why I am used for grave-stones, cisterns, school-slates, roofing-slates, and for many other purposes.

II. My Past History.—(*a*) Youth. After I had lain at the bottom of the sea a long time, I became thicker and thicker, as more and more mud was dropped on me from above by the rivers flowing over me into my native ocean. Then the sea-bottom where I dwelt was lowered down, and other things were washed over me, such as sand. So at last I was buried far and deep out of sight.

(*b*) Middle Age. Then I found that I was getting warmer and was drying up; and the great weight above me also pressed me closer and tighter together; so that instead of remaining mud any longer I became clay. Time went on, and the weight above me grew greater and greater, as fresh rocks covered me over; and the heat also became greater and greater. Then I felt that the ground was being raised up around me, and that great mountain chains were being slowly forced up, higher and higher, squeezing me tightly between them as they rose, until I was ready to split into thin plates, as you see I now do.

(*c*) Old Age. Then came my turn to be lifted up out of my grave, and brought up to the light of day. What a different thing I am now since the day I was at the bottom of the deep sea. Now I am hard, and can beat back the waves and dash them into foam. Now also I can look out over the broad Welsh valleys on the sea and at the streams at my feet. It is only when men come with

their crowbars and their gunpowder, that they can turn me out of the place where I have lain so long.

III. The Old World.—And what a different world I look at now, from what there was when I was being washed by rivers as a fine mud into the sea. Then there were only mosses, ferns, and reeds to cover the earth; not a flower to be seen, not even grass nor trees; now all seems lovely to gaze upon.

But the same sun was shining then that shines now; and the winds and rains beat, and the waves of the sea rippled then, as they do now. This you may see, for I am in many places covered over with the ripple-marks. These were left by the tide, as it flowed and ebbed away, while I was soft, and before I was covered with sand blown over me by the winds, or washed over me by rivers or waves.

Many of my beds are also marked with rain-drops, showing where the rains fell on me when I was a mud-bank.

I am also cracked by the heat of the sun, as you will find the dried-up bottom of any pond to-day.

In my early days there was not much life in the waters over my head; and what animals there were then were pretty much alike. There were not then so many different kinds of living creatures as there are now. But even then there were some live things crawling about in the waters. But as these died, they sank down into the soft mud; and you will sometimes find their shells as "fossils" in some rocks.

But hard as I am, I shall also wear away in time. If you stand on the shore where my bold rocks jut into the sea, you will see the beach is made up of my "bones". These are the flat and round pebbles; and they become smaller and smaller, as the waves roll them about, until they are once more ground down into mud.

32. SLATE.

SECOND INTRODUCTORY SPECIMEN LESSON.

I. What Slate is.—If you look at slate closely, you will see that it will split into thin plates. Slate is a rock that splits into flat slices more than any other. It is made of clay. It does not look much like clay now; but this is because it has been dried and pressed close together by the weight of the rocks above it.

II. Uses of Slate.—You have all seen slate, and had it in your hands to write on. You must have all, too, seen it used for

the **roofs** of houses, instead of tiles, or slabs of stone. It is better for this than stone, as it is thinner, and looks nicer. But it lets the heat of the sun through it in summer, so that a house is always hot in summer when it has a slate roof. And in winter it is also very cold underneath this slate roof.

You may have seen slate **cisterns** for holding water, and **troughs** for horses and cattle to drink out of. It is easily cleaned, and fitted nicely together at the joints. It is also used for **headstones** to graves, the names of the dead being cut out on the slate. Softer slates are made into **pencils**, and stones to **sharpen** cutting tools, such as knives, sickles, and scythes.

Slate is mostly grey, blue, or greenish. Some school-slates have patches of a different colour from the rest of the slate, as a patch of green on a dark, or grey, ground.

When first split slates are not fit to write upon. They have first to be put into water until the light-grey colour changes to a darker tint, or becomes nearly black. School slates want cleaning every now and then, or else they become sticky with grease, and then you cannot very well write on them.

III. Where Found.—We get slate out of great mountains of it which are found in Wales and other places. Here it is got out by axes, and bars, and by gunpowder. It is a very busy sight where the men work at getting the slate. The mountains around look wild and bleak; and every now and then the firing of the gunpowder shakes the ground under the feet. There are not very many places where the best slate is found; and we send a great deal of it away in ships to other places, some of them quite on the other side of the world.

33. NOTES OF LESSONS—SANDSTONE.

Apparatus.—Coarse and fine sand in small glass bottles; red, white, brown, and other coloured sandstones in lumps. Some sea-sand and river-sand. Some gravel, and mixed sand and gravel, taken from a gravel-pit. Pieces of quartz, clay, and limestone.

Matter.	Method.
I. Introduction— All dead matter that has never been alive is a part of the "*mineral kingdom*". Part of this mineral kingdom consists of metals. But none of the *stones* on the table (of the list in the "Apparatus" above)	I. Ask the class in what ways a *cow*, a *tree*, and a bit of *rock* are different. (This gives us the "*Three Kingdoms of Nature*".) Next ask what is the difference between gold, lead, etc., and stones and rocks.

NOTES OF LESSONS—SANDSTONE—*Continued.*

Matter.	Method.
are metals, as they are not *bright*, nor *shiny*; they will not readily *melt*, and are not of *one* substance like lead, etc., but consist of grains of *different* substances. *Rocks* may be divided into 5 great groups:— (1) *Sandstones.* (2) *Clays.* (3) *Limestones.* (4) *Granites*, and (5) *Mixtures* of some two, three, or all of these.	(This gives the difference between *minerals* and *metals*.) Ask for a list of the former, and write this on the blackboard, and of the latter side by side with them. Show specimens of these *rocks* on the table. Tell the class that nearly all the rocks of the earth were made out of the *granite*, and that when this "granite" wears away into *powder*, it gives us the stuff of which the *other* kinds of rocks are made.
II. Properties of Sandstones— (*a*) Of *various colours*, but generally *white*, less frequently *red* and *brown*; still less frequently *green*. Compare with variously coloured clays previously given. (*b*) *Rough* to the touch, consisting of grains, fine or coarse, pressed or cemented together; but rather easily crushed into separate particles. Contrast with greasy soft clay. (*c*) The grains are generally of *irregular shape*, as are the larger lumps. Sometimes they look round, or nearly so. They are, however, mostly *smooth*, through rubbing against each other in the sea and in rivers. They have been polished by rubbing together. (*d*) Some of the particles are *glassy* in appearance, and *reflect* the *light* as *quartz* does. In this respect they are very different from clay or earth.	II. Show all the sandstone specimens that the school has. (*a*) Ask for the *colours* of the specimens, and enquire which is the *commonest* colour in the specimens. Refer to other coloured *sandstones* in any buildings near the school. (*b*) Illustrate by the roughness of *sand-paper* and by the *scouring* of pots, paste-boards, etc., with fine sand. *Crumble* a bit of soft sandstone, and show the class the *grains* into which it separates. (*c*) Have a bottle of *coarse* sand on the table, and tell the class that the particles of this are very like those of the finer sand in *shape* but not in *size*. Ask a child with good sight to examine a lump of coarse sandstone, and to say what shapes the separate grains in it have. (*d*) Show a piece of *pure* quartz, and also quartz embedded in *other* rocks; and compare these with powdered sand in *colour*, *lustre*, and *general appearance*.
III. Whence Derived— (*a*) *Granite Foundations.* All the three kinds of rocks (sandstones, limestones, and clays), except a small part of the limestones made out of "shells" of animals, came from the wearing down of the older, harder granites.	III. (*a*) Illustrate by showing some *sea-sand* and *river-sand*, and some of the *native* rocks out of which these have been worn down, gathered from the neighbourhood of the school. Crush a small piece of *granite* to show that this rock also can be broken up.

NOTES OF LESSONS—SANDSTONE—*Continued.*

Matter.	Method.
(*b*) The stuff that makes up sand and sandstones came out of *granites* by the washing away of seas and rivers, and rains and frosts, wearing them down.	(*b*) Ask children to bring to school from the road-side (in the country), a little of the powder from the *stone-heaps* where the men break stones (granite) for road-metal.
(*c*) *This work is still going on.* This is still taking place, and even sandstones *already* thus formed, are again being worn to pieces on sea-shores, in river-beds, and on river-banks.	(*c*) Show the class some *sandstone* from a cliff at the sea-side, and also some *sand* washed down out of this on the shore, and forming there a new sandstone rock to be afterwards laid high and dry, and hard.
(*d*) *The order of the work.* First the *river*, etc., eats away a hard piece of rock, then a *flood* washes this down and breaks off its *corners*, in doing so making pebbles and sand. Then the river washes away the sand.	(*d*) Show the class large, coarse, *angular* fragments; then *coarse sand*, then *fine sand*, and lastly soft mud or *silt*. Shake these up in a bottle to show the order of deposition, the heavier sinking first, as just stated.
(*e*) *Hardening.* After a long time other stuff of the same kind is washed down on the top of this. So the loose sand becomes *pressed* and *hardened.* If now the sea or river dries up, we have a bed of sandstone to dig into.	(*e*) Wet some sand and *press* it hard into a thimble, and turn it out in the form of a *cast* or mould, to show that it will *cohere* under *pressure.* Contrast its weakness in this respect with clay treated in the same way.
(*f*) *Texture.* This work of the river gives us the reason why the grains are so *small* and so *smooth*, and why the sandstone shows *layers.*	(*f*) Rub on a slate some *coarsely powdered* lump-sugar, to show how the grains become smaller and smoother by being rubbed down.
IV. Uses— (*a*) For *building-stone*: of various values, some being loose and easily broken, some hard and lasting, some in large masses, others in only smaller pieces not worth so much.	IV. (*a*) Explain that the "*harder*" the sandstone, the better it wears: and so the better it is for building purposes, unless it is too hard to be worked.
(*b*) The softer kinds are used, (1) Crushed to mix, instead of sand, with *mortar.*	(*b*) Make a little *mortar* before the class from lime and sand.
(2) For making smooth *walks* in gardens, etc.	(2) This is used as it is *clean*, and does not hold the *rain.*
(3) For scouring *floors, boards, sauce-pans, paste-boards,* etc.	(3) Explain that this property is due to its *sharp corners.*
(4) To mix with "gas-tar" for road *asphalt.*	(4) The sand prevents the tar from becoming too *soft* in the sun.
(5) For *ballast* for boats, to keep them from tossing about too much in the water in a strong wind.	(5) Explain that it is *close at hand* on the shore for boats, and can be easily put into and taken out of *bags* ("ballast bags").

34. NOTES OF LESSONS—WOOD.

Apparatus.—Specimens of pine, oak, ash, mahogany, elm, beech, etc., in thin transverse sections of their stems, showing bark, "sap-wood", and "heartwood", and vertical sections of the same; green cabbage stalk, and rhubarb.

Matter.	Method.
I. What wood is— (*a*) *Stems.*—The *stems* of plants large enough to be called *trees.* These stems are *hard*—not soft and fleshy like those of grasses, sugar-cane, etc. These stems are also called "*trunks*". It is out of these that we get "timber" for building, furniture, etc. (*b*) *Bark.*—On the outside of most trees there is a protective covering called *bark*, sometimes *rough*, *hard*, and *thick*, as in oak, elm, etc. Sometimes it is *thick* and *spongy*, as in cork; sometimes *thin*, as in the birch. (*c*) *Sapwood.*—Inside of this bark is the *sapwood*, moister and softer than the centre, full of *sap* or life-juice, and nearest the bark. Timber has to be kept ("*seasoned*") till this sap dries out of it before being used. This sapwood is younger than the "heartwood" within it. (*d*) *Heartwood.*—Beneath the sapwood is the "*heartwood*", or the innermost, hardest, and closest part of the tree's wood or "*timber*". In the centre of all is a small pipe or channel, which in early growth is full of *pith.*	I. (*a*) Remind the class that plants according to size are roughly classed as— (1) *Herbs,* (2) *Shrubs,* and (3) *Trees*; and that the *stems* of the latter are woody, like those of shrubs, but larger than, and unlike those of, herbs. (*b*) Show specimens of these *barks*, and compare and contrast them in *thickness*, *roughness*, and *texture*—and show class manufactured and raw cork. Procure and show specimens of the very thin outer bark of the birch tree. (*c*) Tell the class that the *sap* is the "blood" of the plant. It is drawn up out of the ground through the *roots*, and goes up the *stem* into the *leaves*. Show class the milky sap of the lettuce or dandelion. The *sapwood* ("alburnum") is like the *flesh* over the bony *skeleton* of man. (*d*) Show the hard *heartwood* ("duramen") in vertical and transverse sections of tree stems. This is like the "bony skeleton" of the tree. Show class the first year's growth of elder-bush, and let children see the *pith* in the middle.
II. Properties— (*a*) Some woods are *soft* as elder, poplar, and deal or pine-wood. These generally come from quickly growing trees. (*b*) Others are *hard* as oak and beech. (*c*) Some are *white* (white deal), others *yellow* (yellow deal), *brown* (oak), *red* (cedar), *chocolate-coloured* (mahogany), *fawn-coloured* (maple), etc. (*d*) Some are *heavy* and useful for beams and posts in building.	II. (*a*), (*b*) Let the class see difference between *soft* and *hard* woods in *splitting*, in *chopping*, and "whittling" with a knife, in *scratching* with the finger nail, and in resisting a *screw* and a *nail.* (*c*) Ask for furniture made of differently coloured woods. Do the same for the parts of the school-room made of timber, and for any of these of different colours. (*d*)-(*g*) Enquire from the class to what *uses* the *heavy*, and *light*, and the *loose*

NOTES OF LESSONS—WOOD—*Continued.*

Matter.	Method.
(*e*) Others are *light*, and fit for rafters of roofs, for making boats, barges, etc. (*f*) Some are *loose* in texture, as poplar and willow. (*g*) Others are *close-grained*, as mahogany, etc.	and *close-grained* timbers can be severally put, and the reasons for the employment of each.
(*h*) Some are easily *worked* with the saw, plane, etc. (*i*) Others are *hard* to work, and turn the edges of tools. (*j*) Some *easily split* along the "*way of the grain*", as in deal. (*k*) Others do so with *difficulty*, as the oak.	(*h*), (*i*) Illustrate the *working* by using a knife or chisel on the different specimens, and show the reason of the differences in working. (*j*), (*k*) Do the same with specimens by means of a chopper, or a knife used as such, and ask when wood is split.
(*l*) Some *burn* readily, as pine-wood or deal. (*m*) Others do *not* readily kindle, as oak.	(*l*), (*m*) Ask class what kinds of wood (compared with specimens) are used to *light fires*. (Pine-wood or deal). Explain that wood is the first kind of fuel used by man before coal was discovered.
III. Uses— (*a*) For *kindling* fires in houses, in stoves, furnaces, etc.	III. (*a*) Explain that coal will not '*catch*' or '*kindle*' so readily as wood.
(*b*) For *fuel* instead of coal.	(*b*) Explain that some countries have *no coal*.
(*c*) For building *houses*, and making *furniture*. This is because it is readily obtained on the spot, and easily worked.	(*c*) Tell the class that all houses used at first to be made of *mud*, then of *wood*, and then of *stone* and *brick*.
(*d*) For making *boats*, *ships*, etc. The first canoes were trees hollowed out by fire.	(*d*) Enquire why *timber* is so well suited for this purpose. (Light).
(*e*) For making *bridges*, railway sleepers, etc. Wood is well suited for bridges because of the length of the beams.	(*e*) Ask class what part of the railway lines are made of timber (sleepers); and make a "bridge" out of pieces of wood.

35. NOTES OF LESSONS—A FIRE.

Matter.	Method.
I. Introduction— In *winter* time when the sun is not sufficient to warm us, we light *fires*. These also serve for *cooking* and *boiling water* for cleaning. They are useful, too, in rooms for drawing in fresh air from outside the house, and sending the bad air up the chimney.	I. Ask the class *when* we have fires in the *living* rooms, and why not in summer. And why we keep up fires in the *kitchen* in summer as well as in winter. (For *cooking*). Ask the class what goes up the chimney. (Smoke.) And what else? (Hot and bad air.) Where has this bad air come from? (Out of the room, from breathing in it.)

NOTES OF LESSONS—A FIRE—*Continued.*

Matter.	Method.
II. Description— The fire is *kindled* with something that will readily *catch alight* and soon *burn*, as paper and shavings of wood, small lumps of coal, then large lumps above these. It is kept up by the air of the room, sometimes aided, if dull, by the bellows to pump in more air. In order that the air may get *to* the fire, and *into* it, the fireplace which holds the fire is not shut up, but *open*. The openings are at the *bottom* of the grate, and at the *front*, the air passing in between the bars in both cases. Above the fire is a *chimney* to carry off the heated foul air, and smoke; and to make the fire burn all the *brighter* by the great *draught* which a tall chimney makes.	II. *Lay a fire* in the school-grate, and get from the class the *reasons* for the successive order of each step in the process, and explain the reasons to those who do not understand them. (To get a quick flame below to kindle what is above.) Show the *result* of blowing with the bellows, and contrast with blowing out a candle. (Too strong a current.) Show that if the air is *shut out* altogether, the fire will not burn, by inverting a tumbler over a lighted candle, which then goes out for want of air. Tell class that a *child* put under a large tumbler, would in same way "*go out*", or die. Light a paraffin lamp *without* a chimney; let class notice the dull flame and great smoke. Now *put on* chimney and notice the result. Increase this result by adding a second *paper* chimney to the glass one to increase its height.
III. Burning— Three things are wanted to *make* a fire and *keep it up*:— (1) *Fuel* (coal, coke, peat, wood, etc.). (2) A supply of *air*. (3) A light to *start* the fire. The *paper*, or shavings, beneath is first lit, and this gives *flame*. The flame "catches" the *wood*, and this gives further flame and *smoke*. The burning wood now sets the *coal* on fire, which gives much more smoke, a little flame, and after a time a dull *red glow*. The smoke turns to flame as soon as it is made hot enough to do so by the fire burning up briskly, or by a flame passed over or through the smoke to heat it. Blowing the fire with the bellows sends more air into it. Where this reaches, the burning or "*combustion*" goes on more rapidly. This gives greater *heat*, and the greater heat turns the smoke into flame, and makes the *dull-red* glow turn to a *white-hot* one. So	III. Get these if possible from the children. Ask what sometimes makes a fire *go out*. Get the different *kinds* of fuel the children have seen used at home, or at school. Ask the class which will catch alight soonest. (The *paper*.) And the next? (The *wood*.) And the last? (The *coal*.) What would be still harder to set alight? (The *coke*.) Then ask the children to notice that what soonest "flames" soonest burns out. Set alight the smoke coming out of the stem of a heated tobacco pipe with the bowl full of coal-ash covered with clay. The class then sees that heated smoke becomes flame. Where the smoke is coming the thickest from the fire in the grate, hold over it a crumpled sheet of newspaper alight. This *heating of the smoke* will turn it into *flame*. If the heat of the smoke is increased by *poking* up the fire, and letting a *draught* through it, flame will burst out. So the way to make a fire *blaze* and

NOTES OF LESSONS—A FIRE—*Continued.*

Matter.	Method.
the fire burns clearer, and greater heat passes up through it; and greater heat comes out from it in front. Our fire now well warms the room, and also boils the kettle or sauce-pan, and is fit for toasting or roasting.	burn with a glow, is to give it plenty of *air.*
The air of the room is now *flowing inwards* from the doors and windows, and through cracks and openings, to get to the fire, and so through the fire to pass up the chimney.	Show the current up the chimney by hanging in front of the fire a thin light strip of tissue-paper, etc. This is blown up the throat of the chimney by the draught. Or a feather dropped in front of the fire will pass up the chimney with the current of heated air.

36. NOTES OF LESSONS—HARD AND SOFT SUBSTANCES.

Apparatus.—As many of the following as possible:—(*A*) Soap, putty, clay, dough. (*B*) Brick, bone, ivory, slate, chalk, india-rubber, wood, glass, emery-paper, lead, zinc, copper, tin, iron, and steel.

Matter.	Method.
I. Hard and Soft Bodies— One substance is generally known from another by differences in *colour, size, shape, hardness,* and *softness.* These are what we call the "*qualities*" of the substances.	I. Let children see how many of the objects mentioned in "Apparatus" they can *scratch* with the finger nail. All these may be considered as *soft,* and the rest as *hard* substances.
II. Relative Hardness— Let children arrange on the table the substances mentioned above, into groups, "soft and hard bodies", according to their *relative* degrees of hardness and softness, beginning with the hardest and ending with the softest. The test should be that the harder one of two substances will *scratch* the other and softer one. They will thus find that glass, steel, and emery-paper are the hardest of all. Refer to the plumber's *diamond* as sufficiently hard to cut glass; and explain the action of sand-paper used to polish the leather soles of shoes, and emery-powder, and fine sand to give brightness to steel.	II. Write down from the dictation of the children the substances used as specimens in the order of their *hardness* on the blackboard, to get their *relative* hardness. Let children try to scratch one with the other, or with their finger nail or a pin; and class these substances accordingly:— *Hard.* (1) Emery-paper. (6) Zinc. (2) Glass. (7) Copper. (3) Steel. (8) Slate. (4) Iron. (9) Bone. (5) Tin. (10) Ivory. (11) Brick. *Soft.* / *Intermediate.* (1) Dough. (1) Lead. (2) Soap. (2) India-rubber. (3) Putty. (3) Wood. (4) Wet Clay. (4) Chalk.

NOTES OF LESSONS—HARD AND SOFT SUBSTANCES—*Continued.*

Matter.	Method.
III. Specially Hard Substances— These are those on the left hand list on the blackboard. *Ironclads* now replace *wooden* men-of-war because of their hard outer skin that resists shot and shell, which timber would not do. Specially hard things, as glass, cast-iron, pottery, etc., may be also *brittle*; but are not obliged to be so, as in wrought iron. Specially hard substances are also often *heavy*.	III. Let children test hardness of *glass* by trying to scratch it with a knife; and of *steel*, by trying to mark it with a file; and of *emery-paper*, by polishing a steel poker with it, showing that it must therefore be harder than the steel. Contrast, for *brittleness*, a steel poker and a piece of slate, or a piece of cast iron and a piece of wrought iron, by striking each with a hammer. Compare, for *heaviness*, a piece of oak and deal, and show that the harder is also the heavier of the two.
IV. The Hardest Substance— This is the *diamond*. (*a*) This will *cut glass*, (*b*) and is also used for *boring* holes through rocks to insert gunpowder for *blasting* purposes, (*c*) and for *testing* the kinds of rocks in the crust bored through, without the expense of digging a shaft (or well).	IV. Ask what the glazier cuts glass with. (Diamond.) Show a glazier's diamond, if possible; and cut or scratch glass with it in front of the class. Since it will cut glass or rocks it must be very hard. Explain how the diamond is used in the "*drill*" for cutting rocks.
V. Coins— Gold, silver, and copper are used to make our coins; but these are rather soft, and would soon wear out. So they are mixed with *harder* substances to make them wear better in use. The copper formerly used to make farthings, halfpence, and pence, was softer than the bronze now used: those coins, therefore, sooner wore out, or had the image and writing on them rubbed out sooner than with those in present use.	V. Ask what a sovereign, a shilling, and a penny are made of. What is added to gold in making sovereigns and half sovereigns? (Copper and silver.) What to copper, for pence, etc? (Tin.) What do we call the mixture ("Alloy") of copper and tin? (Bronze.) All the substances that are mixed with these metals used in making coins and ornaments are harder, and thus lengthen out the use or employment of them or make them last longer.

TEXTILE FABRICS.

37. NOTES OF LESSONS—FLAX.

Apparatus.—Picture of a flax plant, a dried flax plant, a bundle of flax, a coarse comb, linseed growing in water, and in soil, linseed, tow, piece of linen, and skein of thread. (See p. 83.)

NOTES OF LESSONS—FLAX—*Continued.*

Matter.	Method.
I. Description— If we look at the stem of a flax plant, we notice that it is *long* and *thin.* Now if we look at it near the top, we shall see that the *stem* sends out smaller stems called *branches.* We also see that the *leaves* are long, narrow, and pointed. The stem grows about as high as a school desk. When the *flowers* die, *seeds* come in their places, as in peas, beans, etc. The *fruit* is called a "*pod*", and contains ten flat roundish seeds of a brown colour called *linseed.* If we open the pod we see these seeds neatly packed there, ten in each pod.	I. Show class green and dried stems of flax plant, and of a tall grass with flowers like those of the wild oat, that they may see the likeness in *length, thinness,* and *branching* at the top. The *leaves* also are somewhat alike in length and narrowness, but differ in the sheathing character in the one case (grass), which is absent in the other (flax). Get from class that flowers are followed by *fruit,* as in apple, pear, strawberry, etc. ; and that some fruits are *seeds,* as in linseed. Show similar pods of peas, Windsor beans, furze, and scarlet runners or dwarf kidney beans.
II. Manufacture— When corn is ripe, we cut it down, and gather it into the barn ; but flax plants are *pulled up,* and laid on the ground to dry. Next they are taken up in handfuls and drawn through a coarse *comb.* The *seeds* fall out of the plants and are collected in sheets. There is then left a lot of *stems.* The stems are tied up in *bundles,* and put into water. They are left there for about a fortnight, and then taken out and spread out in a field to *dry.* The reason the stems are put into water is to make the fleshy part rotten, and so separate it from the rest of the stem. When the stems are thoroughly dried they are *beaten.* There are then left only some thin threads. But some of the threads are *long,* and some *short.* It would take too long to pick out the short threads from the long ones by hand, so we draw them all through a *comb.* If we do so with the threads in our hands, the long threads are left in the hand, and the short ones in the comb.	II. Point out to class that in the case of wheat, barley, and oats, there are also two parts of the full-grown plant of use to man, the *seeds* and the *stems* (straw) ; but that the seeds are of the greater use. In the flax plant there are the same two useful parts, but here the stem is the more so. Get from the class that we separate the seeds of corn by threshing ; but that would break and destroy the stem of the flax plant, which is the part we most want to keep whole, so a *comb* is used instead of a flail. In the case of straw we keep it dry ; in the flax we rot off the fleshy part to leave the thready part of the stem, or the fibres. Illustrate the nature of this by showing class a bit of "*bast*", or the inner fibrous dried bark of a tree. Compare this action of water with that on potato-tops, etc., which also rot down and leave dry, but not thready, stalks. Compare this separation of long and short fibres of flax with similar result in wool, hemp, cotton, and other "textile" fibres used in spinning and weaving.

NOTES OF LESSONS—FLAX—*Continued.*

Matter.	Method.
The *shorter* ones are used for making strong twine. The *longer* ones are used for making *linen* cloth. Thus *flax* is used for making linen; *hemp* for coarse canvas; *silk* for very fine garments; and *calico* for cheap material.	Show class a bundle of *tow,* and strips of *linen* of various degrees of fineness. Finish the lesson by telling children about the "fine linen" of Egypt used for the dead in burial, and tell them that this would be considered very coarse now; almost as much so as a coarse apron (show this). Also tell class that *everybody* once used to make their own linen in England, and how lasting this was, and that it was therefore handed down from mother to daughter.

38. COTTON.

SPECIAL INFORMATION FOR THE TEACHER.

I. What Cotton is.—Cotton is the white or cream-coloured fibrous covering attached to the seeds of the cotton plant inside the "**capsule**" or "seed-pod".

Flax Plant.

II. Varieties.—There are about half-a-dozen well defined **botanical varieties** of the cotton plant, all belonging to the "Natural Order" of the **Mallows** (Malvaceæ), and limited to tropical and sub-tropical regions. But there are many more **commercial varieties** of cotton, named generally according to the localities from which they are derived, as Sea Island, Mobile, Texas, White Egyptian, American, Uplands, etc. Among these the principal are the following:—

(*a*) That cultivated on the eastern sea-board of the Southern States of **North America** and in some of the **West Indian Islands**, and yielding the famous **Sea Island** cotton, so valuable on account of its **long, strong, and bright** staple.

(*b*) That cultivated in the United States to the **west** of this region, in the valleys of the Mississippi and its tributaries, and furnishing the **bulk** of the cotton wool imported into this country.

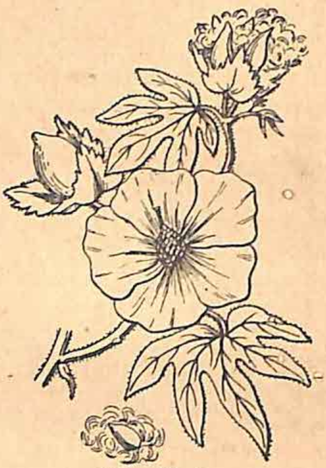
(*c*) A variety grown in South America—chiefly Brazil and Peru —also furnishing a **long stapled fibre.**

(*d*) A **short-stapled** variety, cultivated in the warmest parts of Asia (China, India, and the East Indies), and in Egypt.

(1) That grown in **China** is special on account of its **tawny** colour, and is manufactured into **nankeen** goods, which derive their name from Nankin, in China.

(2) The **Indian** variety is also special, in the sense that it grows on a **tree,** not as the rest, on a shrub.

The **flowers** of the cotton plants are mostly white or yellow, the **seeds** four or five in each capsule.



Cotton Plant.

Cotton Fibres.

III. Value.—The character and **value of the fibre** depend on :

(1) The variety of **seed** used.

(2) The nature of the **soil** on which it is grown.

(3) The **climate** of its habitat.

(4) The mode of **cultivation,** which may be made to improve the staple very much.

The **price** varies correspondingly, and ranges generally from about 3d. per lb. for "Madras", to 13d. for Sea Island cotton.

IV. Special Description.—The individual fibre consists of a **flattened tubular** thread, each with a more or less **spiral** twist, semi-transparent, and with **rounded edges.** At one end it is adherent to the seed ; at the other it runs off tapering to a point.

It consists of the same kind of vegetable substance as that in the woody part of plants (cellulose), but so nearly pure that it is very easily and cheaply bleached.

The length of the fibre varies from $\frac{1}{2}$ an inch in the cheapest Indian to 2 inches in Sea Island cotton. On the average the diameter is about $\frac{1}{1200}$ inch.

The special excellence of Sea Island cotton is due to its regular length, its fineness, regular twist, its strength and elasticity, good and bright colour and appearance, and soft and silky touch.

V. Preparation.—(*a*) The cotton is first picked by hand, when ripe in the pods, or seed-vessels, of the plant.

(*b*) It is next dried to free it from the natural moisture of growth.

(*c*) It is then cleaned, or ginned, by a machine which separates the seeds from the fibre.

(*d*) The cotton wool is next baled, or packed, for the market.

VI. Manufacture.—(*a*) As there are such differences in the characters of the fibres in the different varieties, and also such differences in the same variety, the first necessary operation is that of testing, chiefly according to length of staple.

(*b*) It is next opened, or made loose and disentangled, and at the same time freed from dirt and dust.

(*c*) It is then treated so as to bring the threads alongside each other in order to form a "web" or sheet, and a simple thread is twisted from it.

(*d*) These threads are then doubled, and made into yarn, to increase the strength.

(*e*) The yarn is woven into cloth.

(*f*) The bleaching of cotton consists in the removal of the very small amount of impurities and colouring matter in the nearly pure cellulose of the fibre, by means of alkalies.

39. NOTES OF LESSONS—COTTON.

Apparatus.—Cotton wool, cotton thread, calico, specimens of cotton in different stages of manufacture, pictures of cotton plant, and of a cotton plantation.

Matter.	Method.
I. What it is— Cotton is the white, soft, smooth, downy covering of the seeds of the cotton plant. The flowers are small and yellow, and leave behind them pods or seed-cases,	I. Show specimens of raw *cotton* with seeds in it. Compare these in appearance with *wadding* or fine *wool*. Show a picture of a cotton plantation, with the men and women at work in it,

NOTES OF LESSONS—COTTON—*Continued.*

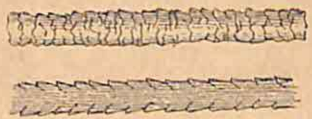
Matter.	Method.
like those of peas and beans, which, when ripe, burst and let out the cotton wool. This is gathered and sent away. The plant is a shrub, with leaves like those of the sycamore; and is planted in rows, five feet apart. It is grown in hot countries.	and deduce from their clothing, etc., what kind of countries the plant is grown in. (Tropical and subtropical, and the race employed in its cultivatio—negroes.) Shew a sycamore leaf, also the ripe fruit of a sedge, of a cotton-thistle, and of a dandelion, as instances of white downy fibres in the vegetable kingdom.
II. Properties— It is made up of *fibres*, or threads, which seem to be, but really are not, straight. It is *white*, and very *light*, like raw wool, but still whiter. It lets heat pass through it freely.	II. Pick out these fibres from the mass. Note the *colour*, and let children feel how *light* the cotton wool is. When do we wear cotton goods? (In summer.) Why? (It is cool.) Refer to boys wearing white calico shirts, and girls coloured prints, etc., in summer.
III. How Prepared— After it has been "*picked*" or gathered in dry weather, it is *cleaned* from seeds, and sent away in ships to be made into calico, prints, etc., sold in England.	III. Explain the "*rolling*" to loosen and get out the seeds, and why it is *pressed* very closely into small space in the ship. The packages are called "bales".
IV. How Made into Cloth— For this it has to go through machines. First the bales are opened and *mixed*. Then the fibres are loosened, straightened out, or *combed*, and *drawn out* between rollers; then *twisted* together or *spun* into cotton thread. Lastly, it is *woven* into calico, etc.	IV. Show specimens of *raw* and *manufactured* cotton. How are the fibres matted together? (By pressure.) Why drawn over combs? (To straighten them out.) Refer to combing our hair. Why is it twisted or spun? (To make it stronger.) Illustrate weaving by Kindergarten work. Pull a piece of cotton rag to pieces to show the threads crossing each other.
V. Uses— Some plants are used for *food*, others for *building* purposes, and others for *clothing*. Cotton is used for clothing, especially in hot countries. It is *cheap* and easily *washed*. It is made into dresses, shirts, sheets, etc. The colours for dresses, etc., are dyed into the material by the "dyer". Prints have "patterns" printed, or stamped, on them. "Fast" colours will not "run" or fade away, in washing. Cotton is also made into sewing cotton.	V. Ask class for examples of each, and the parts of plants severally used. Why used in hot countries? (Fairly good conductor, or it lets the body-heat pass through, and so keeps the body cool.) Compare prices of silk, wool, flannel, etc., with that of cotton. Note that it is often mixed with silk and wool to make these cheaper. Briefly tell how materials are "dyed". Show the class balls or reels of white and coloured sewing cottons.

40. WOOL.

SPECIAL INFORMATION FOR THE TEACHER.

I. **What Wool is.**—Wool is a finer and softer variety of hair, passing from the latter into the former through various degrees of fineness without any hard and fast line of separation.

It chiefly differs from hair in being **curled** (not straight), in the individual fibre; and in having **scales** on the outside, with free edges. The points of these scales are directed, as in those of the fir-cone, to the top or tip; and the points overlap the bases, or "**imbricate**", like the tiles or slates of a roof. This makes the fibre drawn between the finger and thumb from top to base feel rough; while in a hair it feels smooth, as the scales are more closely adherent to the structure beneath them.


Fibres of Wool, as seen under Microscope.

II. **Properties.**—(*a*) Wool is **fibrous**, and the fibre is easily split from tip to base. It has in it an **oily** substance which keeps it soft.

(*b*) It also has more or less of **lustre**, due to the scales reflecting the light. The fibre is either **hollow**, or porous; it is **translucent**, or semi-transparent.

(*c*) It **curls**, or curves, giving a waving or spiral appearance like that of a corkscrew.

(*d*) It "**mats**", or "**felts**", easily, each thread interlocking with others because of the **curved** fibre, and of the projecting scales, or serrations.

III. **Kinds.**—These are very various, including Merino, Saxony, South Down, Leicester, Lincoln, and mohair wools; differing in **length** and **quality** according to the **breed**, the **soil**, and the **climate**.

Thus, **South Down** wool is short and fine ("carding" wool).

Lincoln wool is long and strong ("combing" wool).

The **animals** producing wool are the sheep, alpaca, and some goats.

IV. **Woollen Manufacture.**—This is of very ancient origin, woollen products being mentioned in the Bible.

At present in England the industry is chiefly centred in the West Riding of Yorkshire, and the "West of England".

The raw material passes through the following processes :—

(*a*) **Stapling**, or, sorting according to quality.
(*b*) **Scouring**, in hot solution of soap, to remove grease.
(*c*) **Drying**, on hot pipes.
(*d*) **Teasing**, or arranging into free separate fibres.
(*e*) **Carding**, or making it pliable by beating, etc.
(*f*) **Condensing** into a loose cord.
(*g*) **Spinning** into yarn, in a mill.
(*h*) **Weaving** into cloth.

41. NOTES OF LESSONS—WOOL.

Apparatus.—Raw wool, worsted, flannel, pieces of blanket, and cloth, woollen dress fabrics, saucer of water, coarse canvas, picture of sheep-shearing.

Matter.	Method.
I. Introduction— Let children name from garments worn in the class different materials used for clothing, as cotton, linen, silk, wool, etc.	I. Ask for *source* of each of these materials; and roughly describe each of them in its most characteristic properties, and its suitability for its employment.
II. Properties— Wool is *light, soft, white*, easy to *bend*, made up of fine *threads* ("staples"), able to be squeezed closely; it is a good *absorbent* (will take up water); but it will not let heat pass through it very readily.	II. Show specimens of *raw*, and of *manufactured*, wool. Pull a small piece of wool into *fibres*. Soak a bit of flannel in *water*, and notice how much moisture it will take up. Place a piece of flannel against the cheek, and notice the "warmth" of it.
III. Uses— On account of its properties, it is made by *weaving* machines into cloth, blankets, carpets, shawls, flannel, etc.; and by *knitting* machines into gloves, jerseys, stockings, etc. Stockings are called *hose*; the man that makes and sells them a *hosier*; the trade itself is the *hosiery trade*.	III. Give a general description of *weaving*. Most children will have knitted, or seen their mothers knit, so that they will understand the knitting process. When do we wear very thick flannels? (Winter.) Why? (To keep us warm.) Also ask what is made in hosiery factories. (Stockings, jerseys, vests, scarves, Cardigan jackets, etc.)
IV. How Raw Wool is Obtained— *Sheep-shearing.*—Most of the wool used is *clipped* off the sheep while alive, and this without hurting the animal. In the late autumn and winter the wool becomes very long and thick to pro-	IV. Refer to boy having his own hair cut. (No pain.) Why should wool become long in winter? (For warmth: otherwise sheep would die.) Why does sheep need wool at all? (To keep its skin from chafing on grass, etc.) Why

NOTES OF LESSONS—WOOL—*Continued.*

Matter.	Method.
tect the sheep, which spends most of its time in the cold open fields. In late spring, or early summer, the wool begins to fall off; and the farmer knows this, so he cuts it off instead. In summer and autumn it grows long again, for warmth in winter. This clipping of the wool is "*sheep-shearing*", and the sheep's wool is a "*fleece*". In the early summer the sheep are well *washed* in a brook. They are then turned into a field to *dry*; and after a few days the wool is *clipped* with sharp shears, first from the head and breast, then from the back, belly, and sides.	does wool fall off in spring? (The animal would otherwise be too warm.) Refer to other animals "*casting coats*" in warm weather, and also to *horse-clipping*, and to birds "*moulting*". Describe how the sheep are treated in the water; and how handled by the shearer. Draw a diagram of the shears, and show how they are worked, and that they must be very sharp. What is done with the wool? (Packed into large bales, and sent to market.) Where is the best wool on the sheep found? (Round the middle.) Tell the class that if the sheep are not sheared, they become too hot, and rub their wool off on brambles, hedges, etc.
V. How Woollen Cloth is Made— The *farmer* sells the wool to a "*wool-merchant*", who again sells it to the "*spinners*", and they, by machinery, twist the "fibres" into "yarn" (woollen thread). The spinner sells the "yarn" to the *weaver*, or *knitter*. The weaver makes it into cloth, carpets, blankets, etc., by "looms" (machines); and the knitter into gloves, stockings, jerseys, vests, etc., by knitting machines.	V. Tell children that many years ago women did all the weaving and knitting by *hand*. Show how this was done. Notice the difference in rate of production by hand and machinery: compare with rate of progression of railway engine, and boy pushing a truck. The weaving process can be illustrated by means of the "darning-frame" used in girls' schools.

NATURAL PHENOMENA.

42. DAY.

SPECIAL INFORMATION FOR THE TEACHER.

I. What Day and Night are.—This is a difficult subject for the young class-teacher to understand, without some knowledge of Astronomy. The children will, of course, require to know only of the day as a natural phenomenon, without detailed reference to causation.

The sun rises near the east; reaches its greatest altitude at 12 o'clock at noon; and sets near the west.

It thus describes a visible semi-circular course in the sky. All

the while it is above the horizon it gives us light; and for a short time before it rises, and after it sets, it gives us twilight. Beyond these limits it gives no light to us; and we call that period, night; and the previous illuminated period, day.

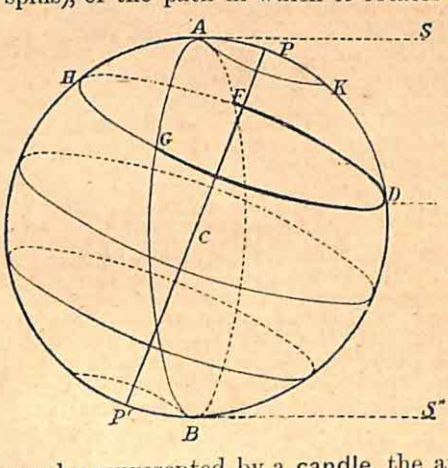
So we may roughly define day as the time occupied by the sun in travelling above the horizon from east to west; and night, as the time during which the sun is below the horizon, or when it is travelling from west to east. But we must remember that the two overlap at morning and evening in the periods of twilight.

So far we have judged only by sight, and according to appearances.

The reverse of all these movements is actually the case. Instead of the sun "rising in the east", the earth is turning round on its axis from west to east. This brings about the same natural phenomena;—the light of day being visible as soon as the earth at a given spot is turned towards the sun, and reversely.

II. Special Description.—The earth rotates on its axis. It makes a complete revolution in about 24 hours (23 h. 56 min. 4 sec.). This is its diurnal motion. The axis thus referred to is an imaginary line passing through the centre of the earth, the extremities of which are called the North and South Poles: or it is the line along which there is no movement of rotation, since a line has no breadth nor thickness, but only length.

If the earth's "axis of rotation" (the peg of the top) were perpendicular to the plane of the orbit (the floor on which the top spins), or the path in which it rotates and moves in going round the sun, then the earth would always present the same part of its surface to the sun at the same time of each day. The circles of light and darkness would also always pass through the poles, and the length of the day would always be the same (12 hours); and equal to that of the night, also 12 hours.



This is seen in passing a globe round the edge of a table, on which the sun may be represented by a candle, the axis of the globe being kept

vertical to the level or plane of the table, which stands here for the plane of the earth's orbit.

But the axis is not vertical, but inclined, as in fig.

Here it is supposed that the light of the sun, s, s″, is coming from the right. All the earth's surface to the right of the circle A.F.B. is illuminated, or it is day there: the other half on the left is in darkness, or it is night there. A very important consequence follows from this inclination of the axis: suppose the circle H.F.D.G. to represent the position of a man at that latitude during the course of 24 hours. His *day* lasts for a time represented by the part of the circle F.D.G. and his *night* at that time of the year lasts for the time represented by the smaller arc G.H.F.

At the extreme points, A and B, a man a little to the right of A is in constant light (there is no night there then); and one a little to the left of B is in constant darkness (there is no day there then).

III. The Astronomical Day.—The preceding day is the one of every-day life.

Astronomers regard the matter from another point, and use the term day to include both day and night, or the twenty-four hours from midnight to midnight.

43. NOTES OF LESSONS—DAY.

Apparatus.—A globe (capable of revolving on its axis, as the "Portable Globe"); diagram ("Day and Night"); ball and candle; orange on knitting needle passed through its centre.

Matter.	Method.
I. Introduction— Introduce by getting from the class the common meaning of "*morning*", "*afternoon*", and "*night*".	I. Ask children what day of the week it is. Tell them you wish to talk about a Day.
II. What a Day is— It is the time taken by the earth to turn round once. If a lighted candle stand for the sun, and a ball for the earth, the class will see that half of the ball is light and half dark. If turned, the dark and light spaces interchange. One turn round of the ball stands for one turn round of the earth, or a day.	II. Illustrate the turning of the earth by that of a globe, apple, or orange with needle through the centre, Or, explain by two boys in front of the class, one made to represent the sun, and the other the earth: the latter turning round, or revolving on his own vertical axis, just as a top spins on a floor.

NOTES OF LESSONS—DAY—*Continued.*

Matter.	Method.
III. Parts of the Day— (*a*) Day and Night in their practical use mean *light* and *darkness.* The earth being round the sun cannot shine on both sides of it at once, but on only one half. The earth turns round, and when the side we are on faces the sun we have *day*; when it is turned from the sun, we have darkness or *night.*	III. (*a*) Draw a diagram on the blackboard, and further illustrate by use of a globe and lighted gas, and show that only one half of the former is illuminated. Turn this round, and show by marking a cross on it, that it has its period of light, and then of darkness. What do we call the dark part? (Night.)
(*b*) The day is also divided into *hours, minutes* and *seconds.* There are twenty-four hours in a full day (meaning a day and a night together); sixty minutes in each hour; and sixty seconds in each minute. These are, therefore, always of one constant length.	(*b*) Deduce these numbers as far as possible from the dial of the school *clock*; also show children the face of a *watch*, pointing out the hours, minutes, and, by means of the "ticks," the seconds. Let them count sixty ticks for a minute, if the watch beats seconds.
(*c*) We call different parts of the day by different names. The early part of the day is the *morning* or *forenoon*; next comes the *afternoon*; and then the *evening* or latter part of the day. *Noon* is 12 o'clock in the day. *Midnight* is 12 o'clock in the night.	(*c*) Get these different names from the children, if possible, and explain the terms, "midnight", and "midday", or noon. Name two or three hours, and ask children to what part of the day these belong: *e.g.* 9 o'clock (in the morning, and in the evening). Refer to the use of *a.m.* for morning, and *p.m.* for afternoon.
IV. Beginning of the Day— With us, and with most other peoples, the day begins and ends at midnight. With some it starts at sunrise, and with others at sunset. Some people count round from midnight to midnight, 13, 14, etc., to "24 o'clock".	IV. What hour is it at midnight? (12 o'clock.) Then the next day starts directly the clock strikes 12 at night. For a day beginning at evening, refer to Genesis ("and the evening and the morning were", etc.). In what division of the day is sunrise, and in what sunset? (Morning and evening.)
V. Names of the Days— There are seven days in a week. They are: (1) Sunday. (2) Monday. (3) Tuesday. (4) Wednesday. (5) Thursday. (6) Friday. (7) Saturday.	V. Tell class that our forefathers who worshipped idols gave these names to the days. Sunday was the day when they worshipped the *sun*; Monday when they worshipped the *moon*. These names should be written on the blackboard.
VI. Sources of Light— In the early part of the lesson we spoke of light, or day; and of darkness, or night. What makes this great difference is the sun. As soon as the sun shines on the part of the earth where we	VI. Recapitulate Section III., and show on the blackboard by the marked globe how sunrise and sunset occur. If we went down a coal-mine, or a very deep well, we should see the stars shining in the middle of the day, because the

NOTES OF LESSONS—DAY—*Continued.*

Matter.	Method.
are, it is light, or day, there. But when it does not, it begins to get dark. Sometimes it is lighter than at others at night, as when we have the *stars* and full *moon*. The stars shine in the day, but the very bright light of the sun seems to put them out in the day-time, so that we do not see them. All these things that give us light without our help are "*heavenly bodies*", or bodies in the sky, or "heavens".	bright light of the sun would not reach the bottom of the mine, or well. Which light is the stronger, the sun's or the moon's? (Sun's.) This is why the night, even with a full moon, is not so light as the day. What other sources of light are there besides that of the sun? (The moon and stars.) This is *natural* light; what sources of *artificial* light have we? (Gas, candles, oils, and the electric light.)

44. THE YEAR.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—The year is the period occupied by the earth in a complete revolution in its orbit round the sun.

The earth has two motions:

(1) Of rotation, on its own axis.

(2) Of translation, or movement forward through space.

Both motions are represented by those of a top, which whirls round on its peg, and at the same time moves forward (but irregularly, according to the slope of the surface on which it travels).

The path in space thus taken by the earth is not a circle with its centre fixed at one point; but rather that of a spiral, consisting of three hundred and sixty-five turns, in an oval round the sun.

II. How measured.—Viewed from the earth the sun seems to be moving among different clusters of stars during the year. This is the reverse of what actually takes place, as similarly also in the day. To see what actually occurs we ought to stand in the sun, and then we should see that the earth in its annual motion passes in front of different constellations. After about three hundred and sixty-five revolutions of our earth, the sun seems to be moving in the same constellation, or cluster of stars as before. We thus judge that the earth has come round to the same point in its orbit from which we began to reckon. That is, the ellipse has been completed, and the year is finished.

This can be illustrated by setting a child to stand on the floor to represent the sun; and employing another to travel round him in

an ellipse. The straight line drawn from the latter to the former, and continued to the school-walls, will touch these at different points, until all the four walls have been cut by the line thus projected on them.

A further illustration is derived from a diagram, S. representing the sun, and E. the earth travelling round it in an ellipse. The centres of these two should be connected by a straight line, which passes out and travels among s, s, etc., representing the stars among which the sun seems to be moving.

These constellations, or clusters of stars, are known as the "Signs of the Zodiac": one for each of the twelve months of the year.

It is easy to determine the length of the day: but very much more difficult to fix that of the year: hence mistakes were made in the first calculations for this, in the absence of a proper knowledge of Astronomy. Later corrections had, therefore, to be made for past errors.

As the year is about 365¼ days, we agree to call it 365, and the fourth one is leap year, 366, which is nearly correct.

45. NOTES OF LESSONS—THE YEAR.

Apparatus.—Tellurion (if possible):—an instrument to show the phenomena of day and night, as well as of the seasons; a portable globe.

Matter.	Method.
I. Introduction— Enquire which is longer, a year or a day. Some children in the class will tell how many *seasons*, *months*, *weeks*, and *days* there are in a year.	I. Ask several of the class their ages, and how often Christmas-day or their own birthday comes, and thus get their ideas of a *year*.
II. What it is— It is the time taken by the earth to go round the sun. A boy moving round a sun marked on the floor will stand for the earth in its journey round it; and we can divide this journey into four parts to represent the four *seasons*.	II. Refer to the origin of a Day. Explain this again by the tellurion, or by a globe, and burning candle; or by a boy in front of the class. Note that the globe, or boy representing the earth, should have two motions: (1) Round itself, on its own axis; and (2) Round the sun, or candle.
III. Parts of a Year— (*a*) *Seasons.* A year is divided into four seasons; *viz.*, *Spring*, *Summer*, *Autumn*, and *Winter*.	III. (*a*) Ask for the names of the *seasons*, and write these on the blackboard, for "spelling". What season is it now? Which is the hottest, and which the

NOTES OF LESSONS—THE YEAR—*Continued.*

Matter.	Method.
In some parts of the world there are only two; hot and cold; wet and dry. In *summer* we get long days and short nights. The long days, with the sun constantly present, give *hot* weather. In *winter* we get long nights and short days. The long nights, with sun constantly absent, give *cold* weather.	coldest season? Show by tellurion, and diagrams, the position of the earth in different seasons. How long does each season last? Deduce the varying lengths of the day without touching the *cause* of this. Show pictures of the seasons and months in an almanac, and ask the varied occupations of men in these.
(*b*) *Days and Weeks.* A day is a smaller part of a year. Roughly speaking, there are 365 days in a year. Note that in every fourth year there are 366. Seven days make a *week*; and fifty-two weeks one *year*.	(*b*) Compare, and contrast lengths of a day and a week. How many times greater is a week than a day? Ask how many days there are in a year. What is every fourth year called? How many weeks in a year?
(*c*) *Months.* There are twelve named months, and thirteen months of four weeks each, in a year. The named months are January, February, March, etc. The lengths of these months vary; some have *thirty-one* days, others *thirty*, and February has *twenty-eight*, and every fourth year *twenty-nine*. Let class learn: "*Thirty days have September,* *April, June, and November,* *February has twenty-eight alone;* *All the rest have thirty-one;* *But leap-year coming once in four,* *Gives February one day more*".	(*c*) Show the convenience of having a month regularly made up of four weeks. Ask for the names of the months, and write these on the blackboard; and also for the number of days each contains. Let children, if possible, divide the months into the four seasons. Ask for the weather and work done in the fields, and the agricultural products, in each month. Read pieces of poetry dealing with a month in each of the four seasons.
IV. The way in which numbered— The years are counted, or numbered, from about the time of our Saviour's birth. Thus the present year is 1894, or about that number of years since our Saviour was born.	IV. Ask what is the date of the present year. What year will it be in six years' time? If a boy is now seven years' old, in what year was he born? How old is a man in 1894 who was born in 1872?

46. A RAINY DAY.

Matter.	Method.
I. A Rainy Day— Rain falls from the *clouds.* Where does the rain go to? Some *dries up*: some *runs off* the	I. Show by sketch on blackboard, from picture in "Reader" and from "Pictorial Sheet", that two streamlets may rise on the same hill, or mountain, but on opposite

NOTES OF LESSONS—A RAINY DAY—*Continued.*

Matter.	Method.
ground: and some goes *into the ground.* (*a*) Thus rain falls from clouds on the sloping *roofs* of houses; then runs off down the roofs in two directions. (For first notion of "*water-parting*", or *watershed.*) This roof is like a *hill, or mountain,* in turning the rains on opposite sides.	sides of it; and so flow in different, and even in *opposite*, directions. So two children may start from the same school-gate, and turn off in opposite directions, to their homes in streets far apart from each other. Draw diagrams of a *roof*, and *road*, to show their agreement in a double slope.
(*b*) Rain also falls on *roads* (which are sloping, too, though less so than roofs, or hills). The rain-drops here join together to make little streams, or rills, and flow down the sloping sides to the *gutter* on either side, thus making little "rivers" running in little "river-beds".	(*b*) These little "*gutter-rivers*" are like the big rivers, in the same way as a child's model toy engine, or toy tea-set, is like the larger set, or engine.
A large part of the rain thus runs off on the *top* of the ground; but some *sinks in.* This is still more the case in the fields, with the grass and the ploughed lands; this rain after a time flows into the *ditches.*	Ask the children where the rain goes to that falls on the road. Next ask what there is in towns at the sides of the road. (Gutters.) In the country, ask what take the place of the gutters on the roadsides. (Ditches.)
II. The Paths Made by Streams— The rain-streams on the road are: (*a*) *Winding*, not straight. All the streams at last get to the gutter; but each one takes a different path to do so. We see these little winding channels, or beds, made by the rain washing away the soft mud of the road, when the road dries up.	II. (*a*) A child does not take a *straight* path over hilly or bushy ground; it *goes round* the bushes; and *avoids* the highest ground. So our rain-streams wind round stones in the road, and seek the lowest levels. Show class the difference between "*winding*" and "*straight*", by means of a string, stretched, and curved.
(*b*) They always run *down-hill.* The water in the gutter always goes one and the same way, "down the road". This gutter water cannot wind about, since it is kept in its place by higher ground on both sides of it; unless the gutter will not hold all the water. Then the "gutter-river" flows over its sides, or "*banks*", and makes a small "*flood*".	(*b*) Let teacher make the *downward* course of water very clear to the children by pouring a few drops of water on a level slate; sloping this in all directions, to make the water do the same. A "river-bed" may also be moulded in clay, and water poured down it. Tell class to notice that in a street or road on the top of a *hill*, the water will run in the gutter in two opposite directions; but still down-hill.
(*c*) The rain-streams, as they flow, *become larger*, from little "*feeders*", or other rain-streams running into them. There is always more water running down the gutter just in front of the grating down which	(*c*) We call these rain-streams "*feeders*", because they feed the stream; or give it "food" (water). Our body grows *bigger* from taking food (milk): and the baby-stream does the same. A baby also gets *stronger* from food, so does a river.

NOTES OF LESSONS—A RAINY DAY—*Continued.*

Matter.	Method.
it disappears, than higher up the gutter. This is because more and more "feeders", or rain-streams from the road, run into the gutter as the water flows down it.	Call the attention of the children to single rain-drops crawling *slowly* along; and, when several join together, making one larger stream, which then runs down more *quickly*.
At the *top* of a hill there is only a small quantity of water running down the gutters: at the *bottom* this becomes quite a *large* stream. It also becomes very *strong*—strong enough to carry small pebbles, sand, silt and mud with it.	Illustrate all this by rain-drops running together down a window-pane; and imitate these, before class, on an inclined slate, and on a sloping desk.
III. What Rain-Streams Carry Away with Them— These rain-streams on the road *wash out and carry away* with them:—	III. Ask children when their boots and shoes most get dirty, on a dry, on a frosty, or on a wet day. (Wet day.)
(*a*) *Mud.*—This is the finest, softest, and the most easily worn-away part of the road, so it is carried away *first*, even by the smallest showers.	(*a*) Illustrate this by small children carrying away soft mud on their boots on a wet day. Also pour water into a flower-pot, to show the class that the water in running out at the bottom carries off *soil* with it.
This mud is soon dropped down again, in "quiet corners", in hollows in the gutter, and in the grating. It is sometimes drifted into little mounds, heaps, or "mud-banks", round which the little stream then runs, instead of over them.	Show the class some *dried* and some *moist* mud; and *shake* up these in a bottle, to show class how easily both mix with water. Then leave the mixtures to *settle*, to show that the mud drops to the bottom again.
When father hoes up the potatoes, etc., in the garden the ridge he makes is at first quite a little hill; but after very heavy rains, this ridge of earth sinks down a good deal, being washed down by the rain.	Ask class what is at the bottom of every ditch, pond, and running stream near the school, giving these their local names and situations. (Mud.)
(*b*) *Silt* or *sand.*—Bigger rain-streams made by heavier showers wash out and carry away with them *sand* as well as mud; and drop this sand down again afterwards, as they did the fine mud earlier. So in a gutter on the side of a hill, there is sand left at the top, and mud at the bottom of the hill. In a dry pond the sand and pebbles are at the edge, the mud in the middle.	(*b*) Show class some *fine*, and some *coarse* sand; and shake up these in a bottle by themselves, and then together with mud. Call attention to the *coarse* sand settling down first; then the *fine* sand; and lastly the *mud* on the top of the other two. They will thus see which drops down *first* in a river, and which *last*.
(*c*) *Gravel and pebbles.*—Still larger rain-streams in the gutter	(*c*) Do the same as above with *gravel*, and *pebbles*.

NOTES OF LESSONS—A RAINY DAY—*Continued.*

Matter.	Method.
carry down *gravel* and *pebbles*. All these come from the road itself. The road is the "*land*", the rain-stream is "*water*"; so all this shows that "*water wears away the land*". This is true all over the world, wherever there is moving water, whether that be rain on a road, or a mighty river.	Show some "*sharp*" gravel with angular edges; and some *rounded pebbles*, with smooth surfaces. Get from the class how the former are turned into the latter. (By running water.) And that there are all stages of this work shown by the various pebbles.

47. NOTES OF LESSONS—A STREAM.

Matter.	Method.
I. What a Stream is— A stream, or small river, is like a child: it begins as a tiny thing (at the "*source*" or *spring*), and has to be *fed* continually to make it *grow*. If not fed by water (*rain*), it would *dry* up.	I. Draw from children the resemblance between themselves and a stream, as a *tiny* thing at first, made to *grow* by constant *feeding*, and that like a child, the stream would *die* without food.
At first it only *plays* about, *running merrily* down-hill, *singing* over the stones, or *tumbling* down the cliff (waterfall); sometimes getting into a "temper" at trifles.	Further show, or draw from class, how children also *play*, *sing*, and *tumble* about merrily; then become steady, and *useful*, as they grow older.
On more level ground, it becomes quieter and *steadier*; it winds along between its *banks*, getting bigger as it goes through the valley, where many *ditches*, *brooks*, *streams*, and *rivulets* join it and make it larger.	Let class note that the first part of the *life* of the stream, and of the child, is the most *noisy*, *fussy*, and full of motion. As both grow older they become less *prattling*, and less skipping in their motions. The children should be encouraged to make these comparisons, to cultivate their *fancy* and sense of *humour*.
Then it begins to be *useful* for *boats*; and sometimes steamers and *ships* sail on it; and people build big *towns* on its banks; and use the river for many purposes, boating, trading, washing clothes, and bathing; sometimes for drinking; to drive machines, etc. It thus becomes the servant of man, and does *work* for him.	It thus becomes a *worker*, as a child does when it grows up. Ask class in what ways young and older children, men and women, can be useful. Let class note that *work* is the final end and purpose of all our lives. Also remind children that there are "*natural forces*" (those of winds, waves, etc.) that work for *man*.
II. Parts of a River-Course— (*a*) *Course.*—The river begins as a stream; it becomes larger, deeper, and wider, fed by ditches, streams, and feeders, that "run" or flow into it on both sides.	II. (*a*) What makes the baby grow? (It has milk.) What would happen if mother did not give the baby any food? (It would die.) In the summer, when it is very hot and dry, and there has been

NOTES OF LESSONS—A STREAM—*Continued.*

Matter.	Method.
Sometimes the river is nearly *full*, sometimes only a little stream runs trickling on. This depends on the great or small quantity of water coming down in rain and running into the river. In very dry weather some rivers dry up altogether for months.	no rain for a long time, what has become of the water in ditches and the river bed? (It has dried up.) Refer all the points mentioned to *local illustrations*: the smallest brook will suffice: and in the absence of such, fall back on the *gutter*.
(*b*) *Waterfall.*—If in running downhill there is a very steep place for the river to run over, it does so all at once, with a leap and a bound. This gives us a "*waterfall*". Some waterfalls are higher than a house or a church steeple. The water is dashed into clouds of foam as it tumbles on the rocks at the bottom. These "waterfalls" are generally found on the sides of very steep and high mountains.	(*b*) Explain the meaning of "*waterfall*", as a falling of water, or a fall of water over the edge of a rock to a lower level. Make a "waterfall", by pouring water on a slate placed almost horizontally: and by letting water run off the sloping sides of a desk to the floor. Show a picture of a cataract and waterfall, and call attention to the spray and mist rising into the air from the bottom.
(*c*) *Banks.*—The river is kept in its bed by the *banks* on both sides, just as the gutter was. If there were no banks, the water would flow all over the country. The river makes its own bed; and in doing so, leaves banks on both sides.	(*c*) Explain a river's "*banks*", by reference to the banks of a ditch. Get from the class that there are two of these; and that the water runs between them, and that these banks may be steep, or rocky, or almost flat.
The *bed* is the part over which the water actually runs. Or, it is the part between the banks. Boys walk on the bed when they walk in the water of the river, but they leave their shoes behind them on the *banks*. The bed is the *lowest* part of the river.	If there is no river near, illustrate by a *canal* with its barges for the "*useful*" side of the question; and in the absence of this, show *pictures* in school readers or Geographical pictorial sheets of boats, barges, banks, and bed, etc.
III. Towns on Rivers— Most large towns are built *close to rivers* or "on" them, as we say; though the houses are not, of course, built on the water. Sometimes the buildings are all on *one* side, or "bank", of the river; sometimes on *both* sides. In the latter case the two sides are joined by a bridge, or bridges.	III. Ask what river runs near the school; and if any children have seen it, and if so, where. Of what *use* is it to the town (or village)? How do men get across it if there are no boats? (By bridges.) If the river is too wide to put a bridge across it, what should we do then? (Go across it in boats or steamers.)
(*a*) These town people will want *bricks*, etc., to build their houses with; *coal* to keep them warm and to make steam; and *food* to eat. These things are brought to	(*a*) *Barges* bring coals, bricks, timber, lime, sand, and other heavy goods on the river. One horse can draw more thus than in a cart on a road. This use of the river is good for *trade*, because it makes

NOTES OF LESSONS—A RAINY DAY—*Continued.*

Matter.	Method.
carry down *gravel* and *pebbles*. All these come from the road itself. The road is the "*land*", the rain-stream is "*water*"; so all this shows that "*water wears away the land*". This is true all over the world, wherever there is moving water, whether that be rain on a road, or a mighty river.	Show some "*sharp*" gravel with angular edges; and some *rounded pebbles*, with smooth surfaces. Get from the class how the former are turned into the latter. (By running water.) And that there are all stages of this work shown by the various pebbles.

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Matter.	Method.
I. What a Stream is— A stream, or small river, is like a child: it begins as a tiny thing (at the "*source*" or *spring*), and has to be *fed* continually to make it *grow*. If not fed by water (*rain*), it would *dry* up. At first it only *plays* about, *running merrily* down-hill, *singing* over the stones, or *tumbling* down the cliff (waterfall); sometimes getting into a "temper" at trifles. On more level ground, it becomes quieter and *steadier*; it winds along between its *banks*, getting bigger as it goes through the valley, where many *ditches*, *brooks*, *streams*, and *rivulets* join it and make it larger. Then it begins to be *useful* for *boats*; and sometimes steamers and *ships* sail on it; and people build big *towns* on its banks; and use the river for many purposes, boating, trading, washing clothes, and bathing; sometimes for drinking; to drive machines, etc. It thus becomes the servant of man, and does *work* for him.	I. Draw from children the resemblance between themselves and a stream, as a *tiny* thing at first, made to *grow* by constant *feeding*, and that like a child, the stream would *die* without food. Further show, or draw from class, how children also *play*, *sing*, and *tumble* about merrily; then become steady, and *useful*, as they grow older. Let class note that the first part of the life of the stream, and of the child, is the most *noisy*, *fussy*, and full of motion. As both grow older they become less *prattling*, and less skipping in their motions. The children should be encouraged to make these comparisons, to cultivate their *fancy* and sense of *humour*. It thus becomes a *worker*, as a child does when it grows up. Ask class in what ways young and older children, men and women, can be useful. Let class note that *work* is the final end and purpose of all our lives. Also remind children that there are "*natural forces*" (those of winds, waves, etc.) that work for *man*.
II. Parts of a River-Course— (*a*) *Course.*—The river begins as a stream; it becomes larger, deeper, and wider, fed by ditches, streams, and feeders, that "run" or flow into it on both sides.	II. (*a*) What makes the baby grow? (It has milk.) What would happen if mother did not give the baby any food? (It would die.) In the summer, when it is very hot and dry, and there has been

NOTES OF LESSONS—A STREAM—*Continued.*

Matter.	Method.
Sometimes the river is nearly *full*, sometimes only a little stream runs trickling on. This depends on the great or small quantity of water coming down in rain and running into the river. In very dry weather some rivers dry up altogether for months.	no rain for a long time, what has become of the water in ditches and the river bed? (It has dried up.) Refer all the points mentioned to *local illustrations*: the smallest brook will suffice: and in the absence of such, fall back on the *gutter*.
(*b*) *Waterfall.*—If in running downhill there is a very steep place for the river to run over, it does so all at once, with a leap and a bound. This gives us a "*waterfall*". Some waterfalls are higher than a house or a church steeple. The water is dashed into clouds of foam as it tumbles on the rocks at the bottom. These "waterfalls" are generally found on the sides of very steep and high mountains.	(*b*) Explain the meaning of "*waterfall*", as a falling of water, or a fall of water over the edge of a rock to a lower level. Make a "waterfall", by pouring water on a slate placed almost horizontally: and by letting water run off the sloping sides of a desk to the floor. Show a picture of a cataract and waterfall, and call attention to the spray and mist rising into the air from the bottom.
(*c*) *Banks.*—The river is kept in its bed by the *banks* on both sides, just as the gutter was. If there were no banks, the water would flow all over the country. The river makes its own bed; and in doing so, leaves banks on both sides.	(*c*) Explain a river's "*banks*", by reference to the banks of a ditch. Get from the class that there are two of these; and that the water runs between them, and that these banks may be steep, or rocky, or almost flat.
The *bed* is the part over which the water actually runs. Or, it is the part between the banks. Boys walk on the bed when they walk in the water of the river, but they leave their shoes behind them on the *banks*. The bed is the *lowest* part of the river.	If there is no river near, illustrate by a *canal* with its barges for the "*useful*" side of the question; and in the absence of this, show *pictures* in school readers or Geographical pictorial sheets of boats, barges, banks, and bed, etc.
III. Towns on Rivers— Most large towns are built *close to rivers* or "on" them, as we say; though the houses are not, of course, built on the water. Sometimes the buildings are all on *one* side, or "bank", of the river; sometimes on *both* sides. In the latter case the two sides are joined by a bridge, or bridges.	III. Ask what river runs near the school; and if any children have seen it, and if so, where. Of what *use* is it to the town (or village)? How do men get across it if there are no boats? (By bridges.) If the river is too wide to put a bridge across it, what should we do then? (Go across it in boats or steamers.)
(*a*) These town people will want *bricks*, etc., to build their houses with; *coal* to keep them warm and to make steam; and *food* to eat. These things are brought to	(*a*) *Barges* bring coals, bricks, timber, lime, sand, and other heavy goods on the river. One horse can draw more thus than in a cart on a road. This use of the river is good for *trade*, because it makes

NOTES OF LESSONS—A STREAM—*Continued.*

Matter.	Method.
them by boats, up and down the river, some from places near, others from countries a long way off. (*b*) But the people will have to *work* also. They will therefore have to go about, and bring things to make into goods, such as leather for making shoes, etc., and the work when made up will have to be sent away. The river is used for all these purposes.	the carriage cheap, and so the goods cost less to the buyer or user. (*b*) People go on it in boats, or in larger *steamboats*, which carry people and goods. This was more so in olden times, when there were no railways, than it is now. But it is still done when time is of no consequence.
IV. Mouth— We have compared the river to a *child*: but it is also like a *snake*, in *winding* about, and in having a *mouth*. The *mouth* of a snake is the part that *opens*; so this part of a river is open; only it is *always* open. The mouth is never closed. If it runs into the sea, it is open to the sea at the mouth. The *tide* can run up the river through the mouth, as water would run down and into a snake through its open mouth. If the river be only a feeder of another, the "mouth" will be where it joins the larger river. Each little stream running into a pond is a picture of a river running into the sea.	IV. The river is like a snake in the sense that it is small at the tail and larger at the mouth; and the mouth is *open*. The mouth of a river is the *end* of it, but the "source" was the beginning. At the mouth it is widest, and generally the deepest, as having more water in it there. This mouth is most often at the sea-shore. Remind the children that the river has been *coming down* all the way, and most often finds the sea at the end, or *lowest part*, of its whole course. Tell the class that though the river has a mouth, it does not swallow the sea, but the sea swallows the river; for the sea is larger than the river.
V. Differences between Canal and River; also between Canal and Railway— (*a*) The river is made by *God*, the canal by *man*. (*b*) The *river* keeps getting wider and wider on account of feeders flowing into it: the *canal* is of the same width throughout and has few feeders running into it. We only want the canal to be wide enough to give room for our boats, etc., to pass each other. (*c*) We have seen that the river *winds* about, to get round things	V. Draw from children these facts:— A *canal* is a "waterway," as a river also is, but is different from it. (*a*) The river makes its *own* bed; but the bed of a canal is dug out by *man*. (*b*) The canal is made by man just deep and *wide* enough to give room for the great barges. Canals are made from one river (or town) to another. So a boat or barge on the river can travel across to another river a long way off, along a canal between the two. (*c*) A river *winds* about, twisting like the letter S, but a canal is cut as straight

NOTES OF LESSONS—A STREAM—*Continued.*

Matter.	Method.
in its way. But in making a canal, we cut *through* these obstacles, and keep the canal *straight*, and nearly *level*.	as can be (like a road) to save time, trouble, and expense.
(*d*) The river is always *in motion*, as the water runs down-hill. The canal water is (nearly) *still*, because it is on a level. The running down of the river helps boats, etc., when they are going *down* the river. But it hinders them when they are going *up* the river. If the river runs very swiftly, boats cannot go up it at all, and the river is of no use for this purpose. In the canal, it is easy for the boats, barges, etc., to pass along (if the wind is only favourable). In the canal a *horse* draws the boat; this takes the place of the running of the water down-hill in a river. Or the barge is driven by the wind blowing on the sail, while the man steers. If we came to a sheet of water, and did not know whether it was a river or canal, we should see: (*a*) Whether the water was *still*. (*b*) Whether it was all of the same *width*. (*c*) Whether the banks looked as if they were made by *hand*, that is by man, or not.	(*d*) The water in a canal is *still*; and does not tumble down a hillside at the start, nor is it in a hurry to get down to the sea like a river. It is as quiet at the beginning as at the end of its journey, for its source is level (or is made so). A boat can go on a canal as quickly in one direction as in the opposite. Why? (The water is nearly level in the canal, so there is no current to help or hinder the boat.) Make a clay model of a canal, closed at both ends; and fill it with water. A further method is first to get the *likeness* between rivers and canals from the class. Both have *banks* (right and left) and a *bed* to be in: then contrast them on this point. If there are rivers or canals in the neighbourhood, illustrate the likenesses and differences from them. If not, explain each point in the text, illustrating by *pictures* in a reading book, or in the Geographical Chart.
Sometimes when much rain has fallen, a river's bed will not hold it all. Then the river "*floods*", or overflows its banks. A canal does not do this, because we only let water into it at one end. It has no feeders.	Ask class what would happen if we were to try to stop up a river. (The running water would overflow its banks.) But we *do* stop up a canal, and it does not overflow. Why is this? (There is not much running water constantly flowing into a canal; it is (nearly) always the *same* water, lying still.
In a *new* country there are rivers; but there are no canals till we make them. They take a long time to make, as all the earth, etc., has to be dug out and removed. But we can dig out a canal right through a mountain, by making a tunnel for it: and so get goods from one side of a moun-	Why do men have to pay for their barges to go along a canal, when they mostly do not do so along a river? (The cost of making a canal is great.) Canals do not get deeper and wider as they go on, as rivers do. Why is this? (There are no feeders to canals.) A *river* cannot go through a mountain, but it can flow round it, and in time wear

NOTES OF LESSONS—A STREAM—*Continued.*

Matter.	Method.
tain to the other, without carrying them over the top. Where the river becomes very small and shallow, near the source, boats cannot go up it. But we can dig a canal there, to join the beginnings of two rivers together, and so carry our goods up one river, and down the other. Canals are *useful* to take from one place to another very *heavy* goods, which would cost too much by rail. Barges are large, slow, flat-bottomed boats made for carrying coal, bricks, etc. They do not go above four miles an hour—and often not so quickly as that. So they are not now used for carrying *people* though they used to be so. In mountainous countries there are no, or few, canals, but in *flat* countries generally very many. There is one flat country where nearly all the travelling is done on canals; and this country seems full of them—and indeed is as full as ours is of roads.	away its sides, so that by and bye, the mountain is all carried away by the river. But barges on canals go much more slowly than trains on railways, so they only take goods which will not spoil by *keeping*;—not such goods as fruit, fish, vegetables, etc.: these must go by rail. Canal barges are drawn by *horses* but railway waggons by a *steam engine*; so the latter go faster. Canals help to make *rivers* more useful still, by joining one with another (all over England). Explain to the class that the river was first there, and the towns were afterwards built on, or near it. Explain why men live on these sites. (For bathing, washing, or for watermills, boating, etc.)
VI. Rivers on Maps— Show on a *map* the winding black lines that represent rivers. Point out the *sources* of these marked by thin lines, and the *mouths* by wider openings near the sea. Also trace with the pointer the *course* of the river between the source and the mouth; the *feeders* or *tributaries* flowing into the main river; giving the sources of all these feeders, and the wide sweep of country on both sides included within a dotted line to enclose the river *valley*.	VI. Refer to a *map* on the *floor* (making the children quite understand that it is only hung up generally for convenience, that all may see it. Its *proper* position is level, as the ground they walk on). Illustrate by the Thames in the following order:— 1. *Source in hills* (without naming them). 2. *Winding course.* 3. *Feeders.* 4. *River bed.* 5. *River banks.* 6. *River valley.* 7. *Mouth.* Further illustrate by drawing all the above on the blackboard.

48. NOTES OF LESSONS—THE OCEAN.

Matter.	Method.
I. Oceans and Seas— These are moving salt water. Rivers are *fresh* water. The large body, or sheet, of *salt water* covering three quarters of the surface, or outside, of the earth, and surrounding all the land there is in the world, is called the *ocean*. Those parts of the *ocean* near the land are called *seas*; and that part of the land nearest the sea is called the *coast*. Thus the *English coast* is that part of England washed by the sea. When people go out in the summer for a holiday, they often go to the *coast*, or to the *seaside*. Some parts of England have no coast, as they are far away from the sea. The sea is nearly always in motion; but not flowing always *one* way like a river. The *wind* makes *waves* come on the top of the water. Waves are sometimes so strong that they can knock a strong man down. These waves "wash", or dash against, the land, and wear it away, much in the same way as, by constant rubbing against the ground, the soles of our boots are worn away, and as even the school stone-steps are worn down by the feet of many children rubbing against them day after day.	I. Show map of the world, and one of England. On the former point out the preponderance of water over land: in the latter show the meaning of "*sea*" and "*coast*". Appeal to those children who have been to the sea-side for the meaning of "waves"; make waves before the class by blowing across a saucer full of water. Ask children to come out and point on the map to an *ocean*, *seaside*, *shore-line*, and *sea*: without asking for the proper names of these. Refer to former lessons on Rivers, and their action in wearing away mud, sand, and gravel. Show the class out of a Reader some *pictures* of the sea in different *moods*; some with smooth, and others with stormy water. Make a toy paper boat, like those used for infants; and put this in a saucer of water. Now blow violently into the water to make *waves*. The boat tosses about on the water. Smear loose dirt, sand, or mud, on the inside of the saucer: let class see that the water now washes this to the bottom of the vessel, to serve as a picture or illustration of the action of waves on a shore-line in washing away the land.
II. Action of the Waves— (*a*) Waves wash away *cliffs*, whether made of hard or soft rocks; the harder ones last longest, and these stand out as *headlands*, *heads*, *promontories*, and some *capes*. The softer rocks wear away soonest. These the waves eat out into *bays*, *havens*, *inlets*, *creeks*, etc. Let the children point out which English coast, east or west, is the more eaten into; also let them name which portions of the coast are composed of *hard*, and which are composed of *soft* rocks.	II. (*a*) Point these out on Picture Sheet; also make a *model* in clay of the various forms of headland, etc., and allow one of the children to thus mould the clay, under the teacher's direction, before the rest of the class. Show specimens of chalk, sandstone, limestone, and granite: let the children see the difference between the crumbling and the harder substances. To represent the softest rocks make wet sand models, and trickle water on these. Also refer to incoming tide on seashore destroying children's sand-castles, etc.

NOTES OF LESSONS—THE OCEAN—*Continued.*

Matter.	Method.
(*b*) The rocks first washed or broken down from cliffs and promontories, by the waves beating against the base, are worn down *first* into *large, slightly rounded masses*; *secondly*, into smaller *boulders*; *thirdly*, into *pebbles*; *fourthly*, into *gravel*; and *lastly*, the waves grind them into *sand* and *mud*.	(*b*) Refer for illustration to river-action previously given; and show specimens of all these rocks, and make it clear that these effects take a *long time* to produce. The specimens should be got near the school, out of a *river-bed*, or from the *sea-side*, or out of a *gravel pit*.
(*c*) Some of this sediment is carried out to sea, and dropped to the sea-*bottom*. Some of it is washed up again by the waves on flat, still shores, as is also done in river reaches. These make a sandy shore.	(*c*) Get from the children who have been to the sea-side as many of these items as possible. In addition, illustrate by *similar* results in beds of neighbouring brook or river. In the absence of these show pictures of flat sandy sea-shores.

PART II.

STANDARD II.

Government Requirements.—"*Thirty lessons on common objects, such as animals, plants, and substances employed in ordinary life, e.g.,*

Horse.	*Roots.*	*Buds.*	*Candles.*	*Cork.*
Sparrow.	*Stems.*	*Leaves.*	*Soap.*	*Paper.*"

—*New Code. Schedule II. Class Subjects. Art.* 101 (*e*).

The class teacher will note that the foregoing requirements imply a subdivision of the items of instruction in the Elementary Science Class Subjects in this standard into:

(*a*) **Mammals and Birds.** } Natural History.
(*b*) **Elementary Botany.** }
(*c*) **Common Manufactured Articles.**

In addition we have briefly continued the lessons in Natural Phenomena introduced in the preceding standard.

INTRODUCTION.

In the **Elementary Zoology** a few **types** of the domestic **Mammals** have been taken (the cat, dog, horse, and cow), with their wild allied species (the lion and tiger); and some instances of the **birds** as types, of which the sparrow, cuckoo, etc., are representative. But the more systematic treatment of these two departments of **Natural History** is reserved for Standard III; "Simple principles of classification of plants and animals": Schedule II.

The articles of common **manufacture** selected for treatment are mainly those which are suggested in the Schedule, since the requirements of teachers in this department are amply provided for in "Common Things", "Familiar Objects", and "Technology for Schools", by the same publishers.

In the lessons on **Plants** special stress has been laid on the absolute necessity of copiously illustrating every lesson by reference to **concrete specimens,** procured mainly by the children themselves. The "**Notes of Lessons**" drawn up on these items have

been practically found most successful in every one of the Board Schools in Leicester. This work has been most operative in inculcating habits of **observation** in the children; in awakening in them a **love of Natural History** objects; in fostering the **reasoning** powers; in detecting likenesses and differences, and adaptations of means to ends; and in strengthening "**expression**" in the statement by the children of what they have found out for themselves, or have learnt from their teachers on these subjects.

The highest grant for the Class Subject of Elementary Science has been thus secured in every Leicester Boys' Board School; and in many instances boys abnormally dull in all other school subjects have become youthful experts in this one, and have for the first time been attracted to school work by the delight derived from this new world of wonder opened up to them.

The effect on some of the younger **teachers** is hardly less marked in the same direction.

The practical experience of the last two years in working out detailed syllabuses on this subject has enabled the author to eliminate whatever in practice had been found to be uninteresting or impracticable; and the subjects and their treatment as now set down here have been found successful to a most encouraging extent.

49. PARTS OF A PLANT.

SPECIAL INFORMATION FOR THE TEACHER.

I. Introduction.—The points referred to in the following lesson may be demonstrated by reference of every item to the wild buttercup of the fields, as the **type** of **Flowering** Plants in general.

II. Roots.—(1) These are made up of **fibres**, and smaller **fibrils** proceeding from the former.

(2) They are **pale white** in colour, when cleansed from dirt.

(3) They have **avoided the light**, and **sought the darkness**, as though gifted with intention and will.

(4) Their distinguishing mark,—separating them from the stem,—is that they have **no leaf buds**, nor **leaves**.

This part of the plant is the **Descending Axis**; as the stem is the Ascending Axis; or

$$\text{Plant} = \begin{cases} (a) \text{ Descending Axis, or Root.} \\ (b) \text{ Ascending Axis, or Stem.} \end{cases}$$

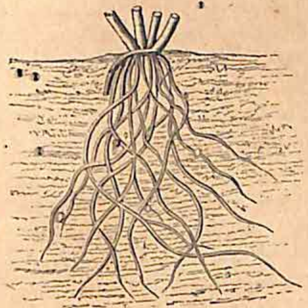
The **functions** of roots are:—

(1) To **support** the plant (buttercup, etc.) in the soil (mechanical).

(2) To draw up liquid nourishment, to feed the stem, etc. (physiological).

Proof of the latter function is seen in dipping into water the roots of a faded plant, when the plant revives.

Besides water, the roots absorb in soluble form out of the soil, such compounds as oxides of potassium, sodium, calcium, and silicon:



Fibrous Root of Buttercup.

Branching Root.

as well as sulphur, phosphorus, carbon, hydrogen, oxygen, and nitrogen.

Proof of this is seen in the presence of many of these substances in the ashes of burnt plants. So the root is to the plant physiologically an organ of nutrition (absorption).

III. Stem.—(Ascending Axis.) In the buttercup this is :—

(1) Green, not pale white like the roots. This is because it is exposed to the action of sunlight, which is not the case with the roots.

(2) It is herbaceous, not woody as in trees: and is thus like the grasses.

(3) It expands into leaves, as nearly all stems do.

(4) It does not seek darkness like the root, but grows towards the light, as if it also had will and intention.

The functions of the stem are :—

(1) To expand into leaves, and flowers.

(2) To expose these to the air and sunlight: the former for "respiration" (through the leaves); the latter for ripening the seeds (in the flowers).

(3) To convey the fluid food found in a soluble form in the soil from the roots to the leaves and flowers; and to build it up in living forms into the structure of the stem itself.

Proof of the latter function is given by dipping into water containing salts in solution, the stems of half-faded buttercup

plants, etc., upon which they revive: and by noting how trunks of elm trees cut down grow twigs out of the sap still left in the trunk when it was felled; and severed willow twigs, and "cuttings" from the garden put forth new stem-structures when placed in damp soil. Observation very largely confirms the two former statements; so stems are mostly mechanical intermediaries or channels for the passage of food-stuff between the root and leaves.

IV. Leaves.—These are expansions of the stem: *i.e.*, they are diminished or attenuated continuations of the stem. All the parts of the stem (bark, woody tissue, pith, etc.), are found also in modified forms in the leaf (in the skin, midribs, venation, etc.).


Lime Leaf, showing Midrib with the Veins.

They sometimes spring as "radical" leaves from the root-stock (as in the primrose): but in other cases they connect with the stem by a "petiole", or leaf-stalk (as in the geranium).

The functions of leaves are :—

(1) To give off moisture, and gases, into the air.

(2) To absorb other gases and moisture from the air.

(3) To elaborate the sap sent up to them from the root, after which it descends to make bark, wood, etc.

The proof of the first function is seen in living and growing leaves on a plant covered with a glass jar, making the glass become dewed with moisture inside; and, when leaves are put into spring water saturated with carbonic acid in sunlight, bubbles of oxygen come off, which may be collected and tested.

So leaves are organs of respiration (gases); transpiration (moisture); and assimilation (elaboration of sap).

V. Flowers.—These, like leaves of which they are modified forms, are on a stalk (peduncle) as in buttercup; or not so as in furze.

In the buttercup all four "whorls", or "flower-circles" are present; and the number of separate parts in each is five (or a multiple of 5). These are :—

(*a*) Calyx, made up of five "sepals", free from each other, subjoined in a tube; green, and regular in shape (all alike). This is the outer protecting coat, or "great-coat" of the flower, to protect (*c*), and (*d*).

(*b*) Corolla, consisting of five "petals", also free from each other; of golden colour, and also regular in shape. This makes

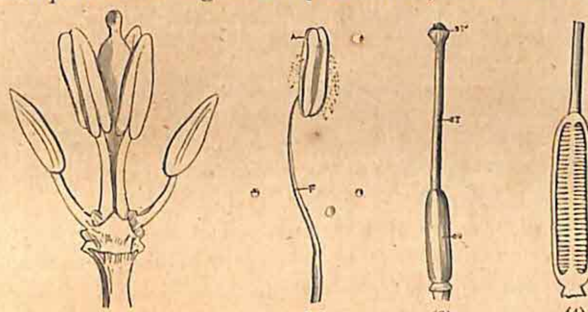
the protecting under coat to (*c*) and (*d*) against wind and wet. (*a*) and (*b*) together, when folded up in the bud, entirely shut in and enclose (*c*) and (*d*).

(*c*) **Stamens** ("dust-spikes"), many; each with a stalk ("**filament**"), with a two-lobed pouch ("**anther**") or pollen-sac at the top; with pollen grains inside of a yellow colour. These anthers shed their pollen, or insects carry it away on their hairy bodies like "dusty millers" do flour.

(*d*) **Pistil** (seed-box), many; separate, one-seeded, in the very centre of the flower. (*a*) (*b*) and (*c*) all exist for the good of (*d*); and (*d*) exists to keep up the **race**, in producing fresh plants.

The **functions** of the flowers are:—

(1) To **reproduce** the race, in Flowering Plants, by means of seeds. This is for the plant itself. The production of flowers is, therefore, the most important of all the functions of the plant, as without this provision the race would perish. Hence the most essential parts of the organs of reproduction (the stamens and pistil)



(1) Stamens and Pistil of Wall-flower, enlarged. (2) Stamen of Lily. (3) Pistil of the Lily, showing the rounded Stigma, the slender Stalk, and the swollen Ovary at the bottom. (4) Ovary of Lily cut open, showing Seeds.

are protected by the two outer lines of defence (calyx and corolla) against wind and rain. But insect intervention is also necessary to make the seeds **fruitful**: these creatures are **attracted** by colour, or by scent, and carry off pollen as the fertilizing agent to other flowers.

(2) Another use of flowers is to furnish in the **seeds** food for man and beast. This is not for themselves, but for others.

(3) They also afford pleasure to man, in

(*a*) **Sweet fragrance,**

(*b*) **Beautiful colours,** or

(*c*) The **two combined** (rarer).

50. NOTES OF LESSONS—PARTS OF A PLANT.

Apparatus.—Several plants, and pictures of plants, with different kinds of roots, stems, leaves, and flowers. A plant growing in a flower-pot.

Matter.	Method.
I. Introduction— Up to the present time all the things we have been talking about in Standard I. were *dead* (*minerals*, etc.). Now we are going to speak about some things that are *alive*, and *grow in the ground*. (*Plants.*)	I. Show a geranium, a fuchsia, and a fern, growing in pots, as *types* of flowering and non-flowering plants in general. Keep these also for future demonstration. Write on the blackboard the three *Kingdoms of Nature—Mineral*, *Vegetable*, and *Animal*.
II. Parts— (*a*) This that I have in my hand is a plant, as it grows in the ground. What is its name? (A geranium, fuchsia, fern, etc.) All the plant is not alike. We see that one part of it grows *under* the ground. What do we call this? (The *root.*) (*b*) Next here is a thick, round, green, longer part, growing above the ground. What do we *call* this? (*Stem.*) Let us look a little closer at this stem. Growing out of it are some *smaller* stems, which we call *branches*, or stalks. (*c*) At the end of each stalk is a broad, flat, green part. In some geraniums these parts are narrow, as in the *scented* geranium; in others broad, as in the *ivy* geranium. What is this called? (A *leaf.*) (*d*) Now here are many other parts, very different in colour and shape from the root, stem, and leaves. What are they called? (*Flowers.*) So we see that a plant is made up of many different *parts*, and to know what we are talking about we give to each part a name. What are all the names of the different parts of a plant from the bottom to the top, or from the birth to full growth? (*Root*, *stem*, *branches*, *leaves*, and *flowers.*)	II. (*a*) Have another plant which can be pulled up by the roots, as growing wheat, grass, etc., previously cultivated in a pot for the purpose. Obtain from the class in what this is growing, and the nature of its *root* (thready, tapering, branching, etc.). (*b*) Next call attention in each case to the *stem* of the growing plant. Cut off a branch of the geranium, show a transverse section of this, peel it to show that it has an outer skin. Ask class for its characters as set down in the "Matter" column. (*c*) Next pull off a *leaf* from the geranium, and call attention to its two parts (blade and stalk). Ask class for plants with large and with small leaves. Point out the differences in shape of geranium and grass leaves, and the green colour common to both. (*d*) Next ask a child to pick a *flower* from the specimen. If it is not the season for these plants to be in flower, show a cut bloom instead. Contrast the colour of these flowers with that of leaves. Ask for other garden (cultivated) and wild (uncultivated) field flowers. Summarise by drawing on the blackboard the outlines of a *typical* plant, putting down against them the names of the separate parts as below :— I. *Root.* II. *Stem* { *Leaves* and *Flowers.*

NOTES OF LESSONS—PARTS OF A PLANT—*Continued.*

Matter.	Method.
III. First Description of Root, and its Uses— (*a*) Where does the root grow? (Under the ground.) Why does it grow under the ground? (To keep the plant *firm* in the soil.) When the wind blows why does the plant *not* fall over? (Because the root holds it down firm.) Here are several different *kinds* of roots;—wheat which has *long, thin* roots; the radish, which has a short *thick* one; the geranium, which is between the two; and a piece of a tree root, which is *woody*.	III. (*a*) Next take up *roots* in more detail. Have a small collection of these to illustrate this part of the subject, viz., —*Fibrous* roots of any weeds; *fleshy* roots of radish, turnip, carrot, or parsnip; and bit of *woody* root of tree or bush. From these get the first rough division of roots, and write their names on the blackboard thus:— *Roots* { 1. *Thready*, like wheat, etc. 2. *Fleshy*, as radish, etc. 3. *Woody*, as in trees.
(*b*) If I keep this plant for a long time, will it always look the same? (No, it will grow larger.) Then, although a plant cannot *see* and *feel* like we do, yet it is *alive*, and *grows*. At first there are only a few little roots, but they grow and send out other little roots, some as fine as hairs.	(*b*) Show class a plant (groundsel, plantain, or any small garden plant in season) that has been *pulled up* for a week, for class to see how *withered* it has become. In the geranium pulled up, show how the main root divides into *smaller* and smaller ones, until the smallest of all (the rootlets) are as fine as thread.
If I pull up this plant, and leave it on this desk for a time, what would happen? (It would *die*.) Then it has died through being *pulled up* out of the ground. What other use does that show the root is to the plant? (It keeps it alive all the while the root is in the ground.) But if we do not *water* the plant, it still dies though the root *is* kept in the ground.	Also show a plant in a pot, that has been kept *without water* for a week, until the leaves have drooped and become limp. Show another that was in the same condition till the day before, when it was *watered*; and ask class what difference there is now between the former and the latter.
So this shows that the root *feeds* the plant, by sucking up moisture out of the ground for it. If this is so, in what way is a plant like a baby? (It must be fed.) What food does a baby take? (Milk.) What food does the plant take? (Water.) In what way are milk and water alike? (They are both liquids.) If we put sugar into the plant's water, what will it "drink" besides water? (Sugar.) There are things in the ground which the water "melts".	Ask children what father does with his weeds which he has *pulled up* out of the ground. (He puts them in a heap, and they *die*.) Ask what happens when he pulls up young cabbage plants out of the bed, and *transplants* them in rows. (They keep alive.) Ask what he is obliged to do to these, if no rain falls, after he has transplanted them, and if the sun is very hot. (He is obliged to *water* them.)

NOTES OF LESSONS—PARTS OF A PLANT—*Continued.*

Matter.	Method.
IV. First Description of the Stem— (*a*) Which part of this plant is the *stem*? (The part of the plant growing up out of the ground towards the light.) What grows on the stem? (Leaves and flowers.) Let us look more closely at these stems. (*b*) Some are *straight*, some *bent*; some *woody*, some *fleshy*; some *thick*, others *thin*; some *rough*, others *smooth*; some *hollow*, some *solid*. Some grow in the ground, others in the air. (*c*) But in all cases the stem spreads the leaves and flowers out to the *air*, *light* and *warmth* of the sun. This then is one of the *uses of the stem*.	IV. (*a*) Point out that while the *root* sought *darkness* and went under the ground, the *stem* rises into the air to seek the *light*. Show class a window-plant in which the leaves have thus turned to seek the light. (*b*) Get class to point out from the specimens the *differences* in stems set down in the "*Matter*" column, and show a collection of stems previously gathered by the teacher and by the children, as ivy stems, elder tree stems, etc., etc. (*c*) Obtain from the class of what *use* the stem is to the leaves and flowers of the geranium and fuchsia.
V. First Description of Leaves— What is this which I have picked off from this geranium plant? (A *leaf*.) We see the leaf is made up of parts:— (*a*) The long, thin, round part called the *stalk* of the leaf; and (*b*) The large flat, broader part, called the *blade*. Now let us look at these *other* leaves. Here are some grass-leaves; of what shape are they? (Long and narrow, like a sword.) Here are rose leaves. (They are broad and short.) Then here is a nasturtium. (They are round.)	V. Show class a geranium, and pick off from it a *leaf* with its *stalk*. Ask class what difference there is between the two parts of which the leaf consists. Ask for comparisons for these: (Spoon, knife, oar, shovel, sifter, Japanese fan, etc.). Show other leaves to fix this division into two parts, and to suggest differences in shapes. Encourage the children here, (1) To *express* in their own words the results of their observation. (2) To make *imaginative comparisons*; even far-fetched ones will be useful.
VI. First Description of the Flower— What is there left now which we have not talked about on this plant? (Flowers.) Let us look at this one. (*a*) Outside we see some very small *green leaves*. (*b*) Then some larger, and *coloured* leaves. (*c*) Inside these are some *yellow balls* the size of a pin's head, each standing on a *stalk*.	VI. Show a geranium, or other plant in flower. Pull a *large* flower to pieces to show the four "whorls"; and lay on a slate each separate part in each "whorl", (as, "sepals" of "calyx"; "petals" of "corolla"; "stamens" of the next whorl; and "pistil" broken up into its segments, inside of all). Do not trouble the class with the *names* of these; but show the *things* themselves instead.

NOTES OF LESSONS—PARTS OF A PLANT—*Continued.*

Matter.	Method.
(*d*) In the middle there is a green ball also on a *stalk*.	
There are then *four* parts to this flower.	Demonstrate the existence of these four divisions on as many flowers as can be got, and as will show them. (Some flowers have not *all* these four divisions.) Compare the outer whorl (calyx) to a *great-coat*; the next to an *inner coat*.
In the summer, when the flowers of the apple tree die, what come in their place? (Apples.) What grow on a plum tree after the flowers are dead? (Plums.) What do we call apples, pears, plums, etc.? (Fruits.)	Show a pea-flower in blossom, with the *pod inside* it, to demonstrate the fruit coming inside the middle part of the flower.
From this we see then that after the flowers die, *fruit* comes in their place.	Show another *very young* pea-pod with the second whorl of coloured leaves (petals) not yet fallen.
So one of the uses of flowers is to make *fruit*.	Do the same for the seed-boxes of the furze, apple, cherry, plum, or pear blossom; also with poppy head, bean flower and pod, and cucumber or vegetable marrow (two different kinds of flowers).
Some *fruits* are *juicy* as grapes; others *fleshy* as apples; others *dry* as nuts. But they all contain seeds, as the *pips* of the grapes and apples, and the *kernel* of the nuts.	

51. THE ROOT.

SPECIAL INFORMATION FOR THE TEACHER.

(FIRST SKETCH.)

I. Introduction.—The general structure of the Root, and its functions in plants have been already briefly demonstrated from the buttercup as a type. We now deal with the Root in detail.

II. Origin.—Seeds are of two kinds; those that—

(1) In germinating send out a "radicle", or first root-form, which elongates by growth.

(2) Those in which the radicle does not elongate, but root fibres push through it.

Dealing with the first kind only, represented by Windsor beans, we notice that when put on damp soil, these absorb moisture, and hence swell up in size; and that the radicle turns to seek the earth, in whatever position the seed may have been placed. This radicle is the origin of the root.

The seed thus acts as :—

(1) A cradle to the infant plant.

(2) As a feeding bottle to it; and also

(3) It contains the baby plant in the form of,

(*a*) An Ascending Axis (stem).

(*b*) A Descending Axis (root). *Vide supra.*

III. Kinds of Roots.—(1) Fibrous Roots, not springing from the radicle, as seen in grasses, etc.

Tap Root of Carrot and Turnip.

(2) Tap Roots, continuations of the radicle, as in the radish, etc.

(3) Adventitious Roots; either from procumbent stems lying on the ground, as in the strawberry plant; or aerial, as in climbing stems, like the ivy. In the latter case, these adventitious roots merely mechanically support the plant; in the former, they do so physiologically, by providing nutriment for the plant.

IV. Functions of Roots.—Special.—Besides the general uses of roots to plants, there is the special one of forming a store-house, or reservoir, of food for future use to the plant, as in the turnip, the tuberous roots of the dahlia, etc. Such plants are thus often biennial, lasting two years; the first year being occupied in growth and storing up food for future use; the second in reproduction (flowering and seeding), from these stored up materials.

The roots of different kinds of plants take up different kinds of food; so different soils are required for different plants; and "rotation of crops" prevents exhaustion of the soil by the same kinds of plants continuously taking away the same kinds of food materials from the same soil.

The growth of the roots is continuous with that of the stem—the more widely the branches spread, the more widely spread the roots also.

Some roots obtain nourishment from other plants, not from the soil; as in the mistletoe, some orchids, etc. ("parasites").

52. ROOTS.

SPECIAL INFORMATION FOR THE TEACHER.

(SECOND SKETCH.)

Apparatus.—Roots of a buttercup and rose plants; turnip; picture of root of tree, and diagram of a root with the root-hairs magnified. Sprouting beans, broad and kidney, and wheat growing in soil, and in water.

I. Position, etc.—Examine some seeds of the pea and the bean plants, etc., which have been a few days in water or on damp soil. Some have become soft and swollen; others kept on the ground longer show two shoots, one pushing upwards, the other downwards. This latter is the young root (radicle); or the part growing downwards, and avoiding the light, by burying itself in the soil. Compare it with the stem: it has no leaves, nor leaf buds, growing out of it. The branches of roots also spring irregularly; in stems this is not so.

II. Shape.—When full-grown, roots differ in shape:—

(*a*) The buttercup root consists of thin thread-like fibres.

(*b*) The bramble has a branching root.

(*c*) The turnip has a thick fleshy root.

Whatever the shape, all end alike in small branches.

III. Uses.—If we pull up a plant, it soon dies:

(*a*) A growing plant needs food.

But, unlike most animals, the plant is fixed in one place; it cannot seek out its food, as most animals do. The food must be near it. To get it, the root stretches out in all directions from the stem. We take in our food at the mouth. The plant also has many mouths in its roots, rootlets, and root-hairs. The growing plant requires more and more food, so it gives out more and more roots: the root of a growing plant cleansed from the soil quickly absorbs water when put into it. This moisture dissolves its solid food in the soil. So cutting away the roots, or pulling the plant out of the ground, cuts off its food-supply, and thereby kills the plant.

(*b*) To serve as a support.

The wind bends trees, etc., but does not often uproot them. This is because their roots spread out around the stem, and beyond the branches. Each lays hold of the soil, and fixes the plant in it. The simple root does not thrust itself into the soil, as we may thrust a stick into it; but penetrates between the particles of earth and wraps itself round them, and so clings to them. The harder, woody roots of trees even grow round rocky masses, and under walls, and thrust up the latter, and even crack them in their increase in bulk.

(*c*) As a store-house of food for the plant's future use.

If a carrot, turnip, parsnip, etc., with dead leaves on it, be planted again in early spring, new leaves, flowers, and seeds appear in the second summer and autumn. The food to make these has been mostly stored up in, and by, these roots during the previous year of growth. This food is used up in the next season of growth by the

new plant. The potato does the same; but not in its roots, but in swellings, or tubers, on the underground stems.

IV. Classes of Roots.—(1) Those that nourish the plant as it grows.

(2) Those that store up food for the plant of the next year.

(1) To the first class belong;

(*a*) Simple, fibrous, annual roots, such as those of the hyacinth.

(*b*) Fibrous, branching, annual roots, such as those of grasses, groundsel, etc.

(*c*) Fibrous in the first year, becoming woody in the next, and thicker and harder each year after, as in most trees.

(2) To the second class belong;

(*a*) Fleshy, round, or tapering roots, that make flowers and fruit in the second year, such as the carrot, radish, etc.

(*b*) Fleshy, branching roots, such as the dahlia.

We therefore deduce,

(1) That plants living through the winter must have stringy roots, as in grasses; or fleshy roots, as in turnips, etc.; or woody roots, as in trees.

(2) That plants dying in the winter need not have these kinds of roots, but roots that die down.

53. NOTES OF LESSONS—ROOTS OF PLANTS.

(First Sketch.)

Apparatus.—Dried tufts of grass with their roots; roots of wheat, oats, barley, flax, plantain, carrot, parsnip, turnip, radish (according to season); part of the woody root of tree or bush; growing plants in pots in school, *e.g.*, geranium, fuchsia; wheat, chestnut, acorn, broad-bean, kidney-bean, mustard, cress, etc., all growing in saddle or loop, or in a bottle of water. Mustard growing on flannel wrapped outside a bottle of water kept overflowing. A hyacinth growing in water (in spring). A sprouting potato (in spring).

Matter.	Method.
A. Uses of Root to the Plant Itself—	
I. Roots *feed* the plant. If we cut, or break off, a stem of a plant from its root, the part withers and dies. But if, before it is quite dead, we put this withered part into water, it freshens up again for a little while. What has	A. I. Show class a withered wheat plant, potato-stem, or other field or garden plant thus *severed* from the root. Show class a stem which has been thus severed, side by side with another, of the same plant, which has *not* been so treated. Refer to a very thirsty *child* pining for

NOTES OF LESSONS—ROOTS OF PLANTS—*Continued.*

Matter.	Method.
freshened up the plant again must be the *water*, for there was nothing else to do this. But the plant, while growing from the root, did not want watering, at least on the leaves and branches outside. Yet it would have died if no water were given to the *soil* or ground. Therefore, there must be some part of the plant in the ground which sucks up, and "drinks" the water we give to the soil.	want of drink, and being refreshed with water. Show class a *pulled-up* plant which has been purposely kept without water a few days to make it partially fade. Show another served in the same way, and afterwards supplied with water. Draw from the comparison of these two, the lesson required, viz., that *roots take up water for the plant from the soil.*
If no *rain* fell to water the roots of plants, they would all die. There are places in the world like this; we call them *deserts*. But where there are neither grass, trees, nor other plants, there can also be no *animals* that feed on these plants.	Get from children what happens when father transplants cabbage plants in the garden, and *no rain* falls. All the plants wither and die. So he uses the *water-pot* to sprinkle the ground where he puts in the plants, and he does this several times.
Next, we will put a little salt, or sugar, in water, to dissolve it. If the plant is watered with this, or if acorns, etc., be made to sprout in this, they will not only take up water, but the sugar or salt also with it. When rain sinks into the ground it "melts" (dissolves) some of the *solid substances* in the soil, as if they were sugar or salt. So the roots of the plant suck up some of these things in the ground, as well as the water in it.	Do this before the class, and get the children to see what they mean by saying the sugar or salt is "melted". Show the class that the sugar or salt is not all gone, by drying some of the solution on a slate over the fire or gas, to drive off the water, as vapour, leaving the salt or sugar behind. Show a piece of marble or soft stone on which marks have been left by the roots of plants taking up the substance of the stone (dissolved or) "melted" out by rain water.
That is the reason why father puts *manure* on the ground. The rains "melt" some of the solids in the manure, and then the roots of the plants suck up these; and this makes the plants grow fast, just as a baby does when it has plenty of *milk*.	Ask the class what father puts on the ground, after he has got up the potatoes, etc., and before he digs up the ground again to set some more. (*Manure.*) Also ask class what the farmer does with the straw and manure out of the farmyard. (He carts it and spreads it out on the fields every year.)
II. *The root fixes the plant.*—Here is a plantain plant; look at the great *number* and *length* of its roots. There is some *soil* still clinging to these. Before the plant could be got up, all this earth had to be pulled up also. The roots therefore *fix the plant in the soil*, and prevent the wind from toppling it over.	II. Lightly *insert* a tall thin stick in the soil in a flower-pot—let class see how slight a push or blow knocks this down. Do the same with a leafy twig, and blow on it; it topples over. Next take the stick and split or subdivide it at one end, and put this forked end into the soil; it does not now so readily fall down. We have roughly made "roots" to it. These prevent it from falling.

NOTES OF LESSONS—ROOTS OF PLANTS—*Continued.*

Matter.	Method.
But a *tree* is much more "*top-heavy*" than a grass plant—its branches spread out much more, so more wind gets at the top to blow the tree over. It must, therefore, have a *firmer hold* of the ground; it must be fastened into it more strongly. It therefore has *longer*, *thicker*, and *stronger roots* than a grass plant. Some trees are not so wide-spreading as others; the poplar is not, so it does not require, and so has not, such long, thick, or strong roots as an oak or a chestnut tree. The rain is kept from the soil under the tree to some degree by the spreading branches and leaves. The roots therefore *grow outwards* also beyond the branches, to get to soil on which the rain will fall. So the more spreading the *branches*, the longer the *roots*.	Show a picture of a *wide spreading* tree (oak, chestnut, etc.); and of a tall *slender* tree (poplar, yew, etc.). Draw one of each of these on the blackboard, drawing the roots also, and making them spread out just a little further than the branches do respectively. Get from the class, that when we set up posts and rails, we make the posts go deepest into the ground, where we want them to be strongest. If the posts are iron, we make them branch out into supports, like the roots of a tree. If the roots of plants do not spread out widely they go down *deep*, as a radish, carrot, parsnip, etc. In either case they catch hold of much ground to hold on by. A clothes-horse also has four feet to two legs. Compare for firmness of support, a stick, a rail with two legs, a three-legged stool, and a four-legged chair.
B. Use of Roots to Man— III. *For eating.*—(*a*) *We eat* some roots of plants, as turnips, carrots, parsnips, radishes, beet-roots, etc. (*b*) Our *domestic animals* also eat roots, as cows and sheep, which feed on mangolds, turnips ("swedes"). We can keep these roots all the winter for them, when there are no other vegetables and no grass for beasts. (*c*) The beetroot is so sweet that it is grown to make *sugar*, and some roots are used to make home-made wine (parsnip).	III. (*a*) Ask children what eatable roots come out of the garden (in the country), or are bought in the greengrocer's shop in the town. (*b*) Get from the class what we feed cows with in the winter time, in the *cow-house* or *dairy-yard* (in the town). Enquire where the farmer puts his mangolds and swedes, to keep them from the frost. (*c*) Ask a child to eat a little bit of beetroot, and tell the class how it *tastes*.

54. STEMS.

SPECIAL INFORMATION FOR THE TEACHER.

(FIRST SKETCH.)

Apparatus.—Pieces of willow and elder. Specimens of stems of ivy, mint, pea, scarlet-runner, etc.

I. Introduction.—We have already seen that a seed in sprouting sends out two shoots, one **downwards** to form a future **root**, the

other upwards, to make a future stem. These are the radicle, and plumule: to become in the end the descending and ascending axes.

II. Uses of Stems.—(*a*) To distribute food to plant. The plant-food sucked up by the roots must go to all parts of the plant. It does so through the stem, which is therefore for this purpose made up of tiny tubes, somewhat like our blood-vessels, but more like the tubes in a piece of cane, which is really the stem of a plant.

(*b*) For support. In trees the stem extends the branches, leaves, and flowers to the sun and air. For this purpose the stem is tough and elastic, to give support against stress in storms. But weaker plants cannot thus stand erect and support their branches and leaves; hence we have:—

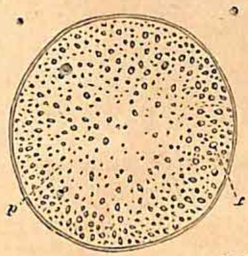
III. Different kinds of Stems.—(*a*) Creeping stems, such as those of the strawberry, spreading out on the ground with strong leaves, clusters of flowers, and heavy fruit.

(*b*) Climbing stems, as in the ivy, pea, vine, etc. These sometimes climb by rootlets on the stem (ivy); in the pea and vine they do so by means of tendrils.

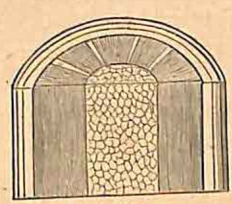
(*c*) Twining stems, as in the scarlet-runner, honeysuckle, hop, etc., twining round poles, strings, etc., set up for this purpose.

(*d*) Underground stems, as in mint, couchgrass (twitch), etc., running underground and sending up frequent branches or offsets into the air. The potato has an underground stem which sends off branches, with new potatoes on the stems, and leaf-buds ("eyes") in the potatoes. A root never has buds on it, the potato underground stem has such, so this is not a "root", as it is sometimes wrongly called.

IV. Size of Stems.—Plants vary in height, giving us three rough divisions into Herb, Bush, and Tree. The size of the stem



Palm. Horizontal Section of Stem.



Oak Stem.

varies according to the weight of the branches, leaves, and fruit supported. The position of the stem, *i.e.*, whether it be erect,

creeping, twining, etc., also affects the size. Compare stems of oak, willow, strawberry, cabbage, grass; and compare also the names variously used, **Trunk, Stem, Stalks.**

V. Parts of a Stem (Tree-Trunk).—(1) In the centre is a white **pith**, surrounded by a sheath (medullary sheath).

(2) Next to the pith are **concentric rings.** (The whole enclosed by **bark.**)

(3) **Rays**, radiating from the "centre", and called "the silver grain".

Rings.—The older the tree, the more rings there are in its stem; a new ring being formed each season of growth. In the Natural History Museum, London, is a transverse section of a tree showing clearly five hundred such rings of growth. The inner, hardest, and oldest wood is "**heart-wood**"; the softer wood is called "**sap-wood**". Stems of English trees (oak, elder, etc.,) increase **yearly** from the outside just under the inner bark. The new rings press closer together the inner ones which thus become harder. The beauty of polished wood depends on the "grain".

55. STEMS.

SPECIAL INFORMATION FOR THE TEACHER.

(SECOND SKETCH.)

I. Introduction.—For **general** outlines of stems refer back to "Parts of a Plant".

II. Origin.—As the germinating seed puts forth a **radicle**, so it also puts forth a "**plumule**", from a bud of the **embryo** of the seed. This plumule, whatever may be the position of the seed in or on the ground, **seeks the light.**

III. Kinds of Stems (more detailed).—Stems are :—

(1) **Herbaceous**, as in the grasses.

(2) **Woody**, as in shrubs and trees.

This is according to their **material substance.**

They are also :—

(1) **Erect**, or **ascending**, as in most trees the woody structure of which is sufficiently strong to sustain their own weight.

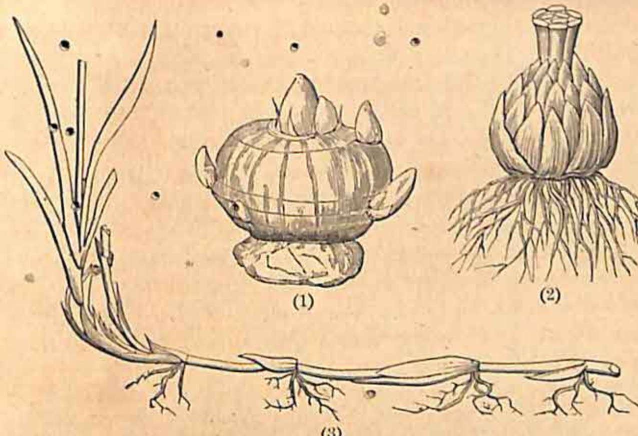
(2) **Creeping**, when the above is not the case, as in the strawberry "runner".

(3) **Underground**, as in couch-grass, etc.

(4) **Tuberous**, or enlarging into receptacles of starch, etc., for the future use of the plant, or the use of a future plant, as in the under-

ground stems of the potato (not to be confounded with the roots proper, having as all stems have, **leaf-buds**, which no roots proper possess).

(5) **Climbing (Scandent)**, as in the ivy, sweet-pea, etc. Sometimes



(1) Corm of the Crocus. (2) Bulb of the Lily. (3) Couch-grass.

the 'hands' that help up the climbers are **adventitious roots** (ivy), and sometimes **tendrils**, or modified leaves (pea).

(6) **Twining (Spiral)**, as in the scarlet-runner, etc., coiling round from left to right or reversely, but always in the same direction for each kind of plant.

IV. Special Modifications of Stems.

(1) **Rhizomes**; these are generally more or less **underground**, and thick, and **root-like** in appearance; as in ginger, etc. They are stems, not roots, since they send out leaf-buds.

(2) **Corms**; these somewhat resemble bulbs in appearance, as may be seen in the "bulbs" of the crocus and arum.

(3) **Bulbs**; these are intermediate between leaf and stem, in nature and position; as in the onion.

(4) **Spines**; these are **suppressed branches**, as in the hawthorn.

V. Growth of Stems.—Stems, according to structure and growth, are divided into :—

(1) **Acrogens**, where the stems increase in size by the union of the **leaf-bases**, as in tree-ferns.

(2) **Endogens**, increasing by the **central bundles** of vessels pushing the old ones outside, as in palms. **Palms** are mostly unbranched,

cylindrical, and tall; without pith, bark, medullary rays, or rings. The outer integument is **inseparable** from the wood beneath and thus differs from bark. The texture is partly **cellular**, with irregular bundles intermixed, and on the outside; hence the hardest wood is on the outside, which is the opposite to the arrangement in the exogens. Some endogen stems are hollow, others solid.

(3) **Exogens**, where the bundles increase on the **outside**, in added external **rings**, as in the oak and most of our trees. These at the first stage of growth have a central **pith**, which afterwards disappears; they also have a **medullary sheath** surrounding this; then woody tissue, consisting of "**heartwood**" ("**duramen**") and "**sapwood**" ("**alburnum**"), with "**medullary rays**" breaking up the woody tissue into wedges; and also a "**cambium** layer" on the outside of the woody tissue; and lastly a separable **bark**.

56. NOTES OF LESSONS—STEMS OF PLANTS.

Apparatus.—Pieces of stems of cane, elder, oak, sugar-cane, ash, elm, pine, hawthorn, etc. Wheat, oat, and barley in the straw, and the whole plants. A piece of bamboo stem; a grass-plant; a fleshy stem in season, *e.g.*, balsam plant in pot; a stem in full leaf, *e.g.*, geranium in pot, geranium in flower. A dried flax plant.

Matter.	Method.
I. The Parts of a Plant— The *stem* is all the plant which rises, or lies, above the ground. It is divided into *branches*, *boughs*, and *twigs*; and these latter generally carry *leaves* and *flowers*. So a plant is made up of two parts:— (1) The part *under* ground; *root*. (2) The part *above* ground; *stem*. This is nearly always the case. Sometimes the roots lie above the ground, or on trees; sometimes, too, the stems grow under the ground, as in twitch (couch-grass, etc.).	I. Illustrate these parts of plants by means of flowering plants kept in pots in school; and by the other articles mentioned in the "Apparatus"; and by drawing on the blackboard a *typical* plant above and below a horizontal line standing for the surface of the ground. Write *root* below the horizontal line, and *stem* above it. Show the class fresh and dried strawberry and ivy stems; also a long strand of fresh or dried couch-grass; or of sand-grass gathered from the dunes or sand-hills at the seaside.
II. Uses of the Stem— (*a*) For *eating by man.*—There are some plants of which almost the whole, except the root, is eaten by us, as in mustard and cress, cabbage, lettuce, etc. There are others of which we eat all except the root and leaves.	II. (*a*) Ask the class what vegetables they get to eat; and from these select such items as are here enumerated, or others put to similar uses. Get class to understand that nearly all our *food* is either *animal or vegetable*; and that we eat more of the latter than of the former.

NOTES OF LESSONS—STEMS OF PLANTS—*Continued.*

Matter.	Method.
(*b*) *For eating by other animals.* But there are also plants all which except the roots are eaten by animals. The cow eats grass, and cow-cabbages; the sheep and horse also eat grass, green or dried (hay). *Hay* is nearly entirely the dried stems of grasses. *Straw* is the same part of wheat, oats, barley, and rye.	(*b*) Ask for the names of fresh *fodder* used in the farmyard; and the materials of the fodder eaten by store beasts in winter. Ask class for the names of animals that are *vegetable feeders*; cow, horse, goat, deer, sheep, elephant, etc., and remind them that most others are *animal* feeders, or beasts and birds of prey.
(*c*) *For Making Articles.*—Rushes and reeds are also stems; but these are not eaten, but used for making furniture (bottoms of chairs, etc.). But it is the wooden stems of *trees* that are most used for this purpose, and for building houses, boats, etc.	(*c*) Show a rush, and a reed; and get children to collect some for themselves. Ask class for different articles of *furniture* made of *wood.* Ask children for different parts of the *house* made of wood. (Doors, window-frames, floors, and joists.)
(*d*) *For Spinning and Weaving.*—Other stems are used for *spinning* into threads; and *weaving,* as flax, and hemp; or for weaving and *plaiting* only, as straw for hats, (bonnets), mats, screens, etc.	(*d*) *Plait* some *straw* into a pattern; do the same with flax and hemp stems. Ask what articles of *dress* are made of flax, hemp (coarse aprons, etc.), and straw. Undo a piece of rope, to show that it is made of hemp (tow).
(*e*) *For Pipes.*—Some stems are *hollow,* and are used for *pipes* to carry water, as bamboo stems. This is in countries where iron is scarce, and where bamboos are plentiful.	(*e*) Show that a grass stem, straw, and bamboo, are hollow. Get a child to suck up *water* through a short length of cane; and *burn* a wick or cane dipped in oil.
(*f*) *For sticks.*—Stems are used for walking-sticks, whip-handles, etc.	(*f*) Point out that these bamboos are *light,* yet *strong,* and will not easily break.

57. LEAVES.

SPECIAL INFORMATION FOR THE TEACHER.

(FIRST SKETCH.)

Apparatus.—Leaves of common *fruit* and *timber*-trees: *e.g.*, apple, pear, plum, cherry; ash, elm, oak, lime, willow, and chestnut; also of *climbers*, ivy, etc.; and of wild and garden flowers, as primrose, geranium, etc.

I. Shape.—Leaves are very variously shaped; but almost always broadest across the middle. Some are **Simple**, or single; others **Compound**, or made up of **leaflets**. Some are **narrow**, as in grasses; others **broad**, as in ivy; others are **notched**, as in rose; **arrow-shaped**, as in sorrel, etc.

II. Colour.—Leaves proper are generally of different shades of green, until they turn sere, or become withered; though some, especially in cultivated plants, are **variously coloured**, as some geraniums, etc. Some are "**variegated**", in shades of pale green, as in some ivies, etc.

III. Parts.—The leaf is an "**expansion of the stem**", and continues the structure of this into its own form. There is:—

(*a*) **The Stalk** (petiole), which forms the connection with, and continuation of, the stem, and consists of woody tissue continued into the **midrib** and **venation** of the leaf, to convey sap, to strengthen the blade, and to expand it to the sun and air.

The **Veins** are **netted** in meshes; or run nearly **parallel** with the length of the leaf.

(*b*) **The Blade** is more or less flat, and horizontal, in this country. Sometimes this is reduced to narrow limits, as in the "needles" of cones, in broom, furze, etc. The blade is really made up of upper and lower layers with a thin skin over the former (seen in the leaves left on damp ground easily separating into these two layers).

The two (*a*) and (*b*) taken together resemble the handle and framework of an umbrella, and the silk between the ribs (veins).

IV. Use to Plant.—(*a*) Leaves take in gaseous **food** (carbonic acid) from the **air**; and build it up into the tissues of the plant.

(*b*) They do the same with **root-food**, elaborating or changing the **sap** derived from the root, and sending it down made fit to form bark, timber, etc.

For the former purpose leaves have **leaf-mouths** (stomata), to take in air-food; for the latter, the veins, full of pipes or vessels, take the sap to and from the stem, and are thus like our blood-vessels, the **sap** representing our blood.

58. LEAVES.

SPECIAL INFORMATION FOR THE TEACHER.

(SECOND SKETCH.)

I. Introduction.—We have seen that the **Plant = Ascending + Descending Axis**: that the former is the **stem**; and that this is expanded into (branches and twigs in trees, and finally into) leaves: and that the latter therefore contain all the elements of the stems in them. This denotes their **origin**. The first, or "seed-leaves", are generally short-lived, and sometimes do not even rise above the ground.

II. Kinds of Leaves.—These may be divided according—

(*a*) To the way in which they come off from the stem (position or arrangement): or

(*b*) According to their **shape** (leaf-form), subdivision, or indentation of outline (margin).

(*c*) According to their **persistence** on the stem.

(*a*) According to their **position** on the stem, they are :—

(1) **Opposite,** if they spring from the **same** level, but on opposite sides of the stem, as in the white and purple bee-nettle, stinging-nettle, etc.

(2) **Alternate,** if they spring one from each joint ("node") of the stem, and, therefore, at **successive** levels, as in the geranium.

(3) **Verticillate,** or more than two in a circle or whorl all round the stem, at the same level, like the spokes springing from the axle in a wheel.

(*b*) According to the extent to which leaves are **divided,** they are :—

(1) **Simple,** when they are entire, or only divided so as not to be separately jointed on to a common leaf-stalk (as in geranium, etc.).

In this case the forms are very various; rounded, heart-shaped (cordate), arrow-shaped (sagittate), pointed, needle-like (acicular), oval, oblong, lance-shaped (lanceolate), spoon-shaped (spathulate), kidney-shaped (reniform), etc. Or, when more indented, they are like the hand and its fingers (palmate).

Compound Serrated Leaf.

(2) **Compound,** when the leaf is divided into separate **"leaflets",** but all connected with the stem by a common leaf-stalk **(petiole),** as in the rose, ash, etc.

(*c*) According to the time they **remain** on the stem, they are :—

(1) **Deciduous,** falling at the end of one season ; or

(2) **Evergreen,** when remaining for more than one season, but giving way to others in succession.

III. Modifications of Leaf-form. (1) **Tendrils,** as in the sweet-pea.

(2) **Spines,** as in the barberry.

(3) **Stipules,** as in the rose.

IV. Functions of Leaves.—(1) Leaves **absorb vapour** from the air; chiefly on the under side of the leaf, which has the thinnest skin. **Hairs** on the leaf help this process. It is more easily done with a **young**, thin epidermis, than when this has become "waxy", and tough, with age. **Washing** the leaves helps the process.

(2) The opposite work of **exhaling** vapour also takes place from the leaf; and also chiefly from the under surface, and where there are most "pores" (stomata). In the "pitcher-plants" the liquid collects. Hence plants affect **climate**, drawing water up from the soil and exhaling it into the atmosphere; and often springs dry up when timber is cut down over large areas.

(3) They convert the **carbonic acid** of the air into **oxygen**, and carbon; the latter being built up into their own tissues: the former exhaled, purifying the atmosphere.

(4) They also **elaborate sap**, and make **secretions** out of it, like miniature chemical factories. Hence diseases, or loss of leaves, darkness, etc., stop these processes, checking the formation of green colouring-matter (chlorophyll), resins, oils, woody tissue, starch, etc.

59. NOTES OF LESSONS—THE LEAF.

Apparatus.—Green and pressed leaves of ash, horse-chestnut, willow, oak, elm, ivy, and lime; also green cabbage, dock, and rhubarb leaves.

Matter.	Method.
I. What Leaves are— The leaf is the stem spread out (expanded) into a broad, flat, thin sheet. In all cases the leaf is wider and thinner than the stem. It has a green, soft part (blade); supported by "*ribs*" which are like the "mid-rib" in the middle, only finer. In a Savoy cabbage the network-veining ("venation") is well seen: and better still in *skeleton* leaves.	I. Show class a dock, cabbage, or rhubarb leaf. Let class see that the leaf-stalk branches out into *mid-rib* and other "*veins*" (venation), made of the harder, woody portion of the stem. Compare this with an umbrella and its "ribs". Show class preserved and dried "*skeleton*" leaves; and explain that the green part has rotted away, leaving the harder, tougher veins.
II. Parts of the Leaf— (*a*) *The Leaf-stalk* ("petiole").—This fastens the blade to the stem (the branch, bough, or twig). Sometimes it is *long*, as in the ash; sometimes *short*, as in the ivy. It is more woody than the "blade", and not so flat.	II. (*a*) Show *leaf-stalks* in the specimens mentioned above. Compare with the handle of a knife, or of an oar. Get a child in the class to arrange the specimen leaves into two heaps; long-stalked and short-stalked. Tear the blade to show how *tender* it is. Try to tear the stalk, and it *resists*. Show in autumn the

NOTES OF LESSONS—THE LEAF—*Continued.*

Matter.	Method.
In autumn it disconnects from the stem by a *joint* which breaks with the wind, or weight of snow, or rain, when the leaf ripens. In spring it would have to be *torn* away from the stem in a strip, as there is no joint then at the junction. (*b*) *The Blade.*—This is the flat part, as in the blade of an oar, a knife, or a sword; but much wider comparatively. It is made up of the tenderer green and the tougher rib portions (veins). Sometimes the blade is *narrow*, as in ash, at others *broad* as in ivy. It is of all kinds of *shapes*, but generally of only one *colour*, green.	smooth scar left at the joint where the leaf-stalk joined the stem before it fell. Tear or strip from a stem a leaf of an evergreen, to show how the stem and leaf-stalk are at first continuous. (*b*) Divide specimen leaves according to the width or narrowness of the blades. Get class to associate the names of trees readily with the shapes of their leaves. Show *broad*-leaved and *narrow*-leaved ivies, to point out that the shapes *vary* much. Illustrate this further by the needle-shaped leaves of fir and yew, and the prickles of furze.
III. Kinds of Leaves— (*a*) *Simple.*—Some leaves are *simple*, or *single*. There is only one on each leaf-stalk; and this is at the end of it; as in cabbage, primrose, lettuce, geranium, fuchsia, etc. (*b*) *Compound.*—Others are *not simple*. There are several *little leaves* (*leaflets*) coming off from the leaf-stalk, each with its own smaller "leaf-stalk", as in the rose, ash, etc. Or sometimes these branch out like a glove or hand, into fingers, as in the chestnut. The ivy has five corners; and in some plants the leaf is divided into "little leaves", right down to the leaf-stalk.	III. (*a*) Arrange the specimen leaves into two groups, according to their *divided*, or *undivided*, character. Give other leaves to the class, and ask children to pick out which are *simple*. (*b*) Ask the class to pick out from the specimens those which are "*not-simple*" leaves. Get from the children in what the difference consists. Call attention to the way in which the leaflets come off from the leaf-stalk in pairs (*opposite*), or not opposite to each other (*alternate*). Tell the class that when a man does not get enough to eat, he becomes a "skeleton"; so do leaves, as in ivy, etc.
IV. Uses of Leaves— *A. To the Plant.*—(*a*) The leaves are like our lungs, and skin: the plants "*breathe*", or take in and give out air through holes in the leaves too small to be seen with the naked eye. So if we keep pulling off the leaves of a plant it will die. This also happens when grubs eat them all off. This is a very common cause of death in both cases.	IV. *A.* (*a*), (*b*) Refer back to the root sucking up water from a bottle, or from the ground. Explain that this passes up the stem, and so stems of growing plants, such as groundsel, lettuce, etc., are full of water (sap). The moisture continues to rise from the stem into the leaf. Bruise a cabbage- or lettuce-leaf, to show that this also contains water. Now this water is always coming in at the root: so it must go away

NOTES OF LESSONS—THE LEAF—*Continued.*

Matter.	Method.
(*b*) The leaves also let water pass away, just as it does in our breath. Leaves shut up under a tumbler, with the sun shining on them, make the inside of the glass misty with a kind of "dew" or "steam".	somewhere. It does not go away till it gets to the leaf, for the leaf is full of it. Therefore, it must pass off at the leaf. The great breadth of the leaf helps this.
B. Use to us.—(*a*) For *eating* and *drinking*, as in salads and tea. (*b*) For *medicine*, as in senna, etc.	*B.* (*a*), (*b*) Get these two uses from the class, and others if possible. Ask what *salads* they know; and make a decoction of *senna*.

60. FLOWERS.

SPECIAL INFORMATION FOR THE TEACHER.

(FIRST SKETCH.)

Apparatus.—Any flowers in season, especially *large* ones, as cucumber, vegetable marrow; and *common cultivated* ones, as geranium and fuchsia; also of *common wild* ones of simple structure, as wild mustard, buttercup, etc.

I. Differences.—(*a*) Flowers differ in **size**; compare a daisy and a sunflower.

(*b*) They also differ in **colour**; being yellow (buttercup), white (snowdrop), pink (apple blossom), red (rose), purple (pansy), blue (wild hyacinth), etc.

(*c*) They also differ in **shape**, some being in three, four, five parts, or multiples of these. Some are flat, others tubular, and others of very various other shapes. But there is still a **likeness** in all flowers.

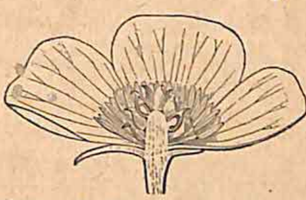
II. Parts.—The **Parts** of a flower generally are:—

(1) The **stalk**, similar to the **leaf-stalk**, the flower being similar to the leaf, and an altered or "modified" form of it. Sometimes the stalk is **compressed**, and cannot be recognised; sometimes it is long and **single**; at other times **divided**; compare stalks of primrose (compressed), and cowslip (long), and buttercup (divided).

(2) The "**flower-cup**" (**calyx**), or outer circle of flower-leaves, not always present; if so, mostly green;—not so in fuchsia,—contrast with geranium. These "protecting leaves" are separate, or joined into a tube; the number of the parts in this whorl has a relation

to the number in the next inner circle, 3 and 3; 4 and 4; 5 and 5; 3 and 6; 4 and 8, etc. In the bud, and before expansion, this part of the flower is like a hood, to protect the other parts inside it from the wind and rain. The separate leaves are called "sepals".

(3) "Flower-leaves" (corolla), generally coloured, to attract insects to visit them. This part is what generally makes flowers beautiful to look at. The separate leaves are called "petals". As in (2) they may be disconnected, or joined into a tube, etc.



Section of a Buttercup, showing the arrangement of its parts.

(4) Dust-Spikes.—(Stamens), well protected from wet and wind by (2) and (3). They are on stalks, with swollen ends above, full of flower-dust (pollen), useful as food to insects, and useful to the plant to make seeds (ovules) fruitful.

(5) Seed-Box.—(Pistil), or seed-vessel, of very various shapes, as pods, etc. Compare fruits (with seed-boxes) of cucumber, apple, pea, etc.

III. Seeds.—These grow in seed-box, and are afterwards scattered, when ripe, by winds, by rivers, and by passing animals; and by their own wings, by hooks, by down, etc.

61. FLOWERS.

SPECIAL INFORMATION FOR THE TEACHER.

(SECOND SKETCH.)

I. Introduction.—We have already seen that the flower is a modification of the leaf-form. This is for a special purpose, that of fructification, and seeding (reproductive). The origin is thus indicated:—the flower being first wrapt up in the form of a bud (as is the leaf also).

The outer of the four "whorls", the calyx, is the least modified, or the most leaf-like; next is the corolla; and so on. Therefore, the calyx is often green, like the leaf; and shows traces of the mid-rib, blade, and other parts of the unmodified leaf-form.

II. Kinds.—These vary very much, according to the way in which the flowers are arranged on the flower-stalk ("peduncle"), as the leaves have been also shown to do.

Among the commoner kinds of arrangement of flowers on the stalk (**inflorescence**) are :—

(1) The **raceme**, with flowers arranged like the berries in a bunch of grapes; each with its short separate stalk, as in the wall-flower.

(2) The **spike**, with separate flowers closer together on the stalk than in (1); as in the plantain, wheat, etc.

(3) The **umbel**, with flowers on separate stalks all springing from **one level** on the common stalk, like the wires of an umbrella, or the spokes of a wheel, the whole forming a flat expansion, like a **wheel**, as in the parsley, parsnip, etc. (Compare with **verticillate** leaves.)

(4) The **panicle**, with irregularly branching flowers, as in the oat, and many other grasses (cereals).

III. Fruit.—The flower prepares for the fruit. Fruits are, of course, as various as flowers. The commoner kinds are :—

(1) **Single-celled**, as in the buttercup.

(2) **Many-celled**, as in the apple.

Some again are :—

(1) **Dry**, as in wheat.

(2) **Juicy**, as in the gooseberry.

(3) **Pulpy**, as in the cherry.

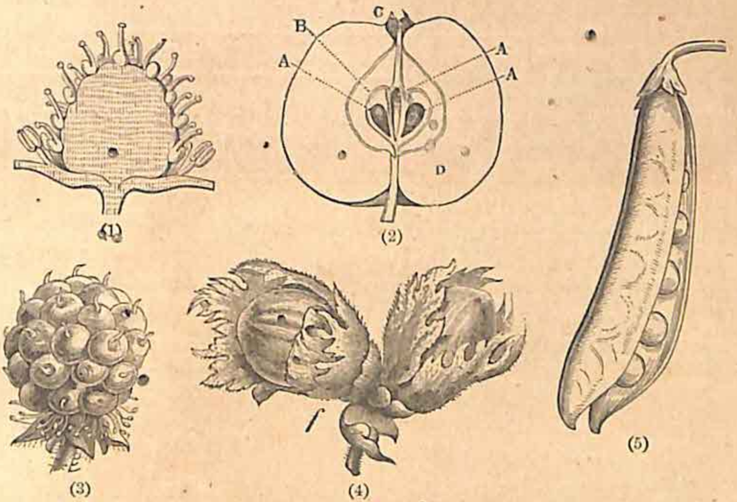
(4) **Fleshy**, as in the apple.

(5) **Woody**, as in the cones of pine, larch, cedar, etc.

62. NOTES OF LESSONS—FRUITS.

Apparatus.—Any fruits in season, as apples, pears, plums, cherries; the different "berries", and nuts.

Matter.	Method.
I. What Fruits are— We have seen that plants generally have *flowers*; and that these flowers die, and leave *seeds* in their places. And we have also seen that these seeds are not often *naked*, but mostly protected in "seed-boxes". All that the flower leaves behind it is called the *fruit*. So the fruit generally contains the seeds, as a money-box contains money. Sometimes the seeds are on the *outside* of the fruit, as in the strawberry; but generally inside, as in the pips of apples, the seeds of gooseberries, currants, figs, etc.	I. Show the class the specimens mentioned in "Apparatus" above; and ask what their names are *severally*; and what name we give to *all alike*. (*Fruits.*) Point out that whilst *flowers* are pretty *to look at*, *fruits* are much more *useful*, as these give us *food*. Enquire from children the names of all the fruits they know (not in the specimen list of "Apparatus" above); as grown— (*a*) In the *garden*. (*b*) In the *field*. Show the *seeds* in as many of the common fruits as can be obtained, and cut the fruits open to show these in place.



(1) Section of Strawberry while forming. The central mass is seen to be surrounded by the Pistils and Stamens of the Flower. (2) Section of an Apple, showing the real Fruit—the *Core*—surrounded by the eatable part. (3) Blackberry. (4) Hazel-nut. (5) Pod or one-celled Seed-vessel of Pea.

NOTES OF LESSONS—FRUITS—*Continued.*

Matter.	Method.
II. Kinds of Fruits—	
(*a*) *Juicy Fruits*: specially the "*berries*"; with a liquid, or jelly-like half-liquid mass inside, as gooseberry, currant, and grape, black and white.	II. (*a*) Show class a bunch of grapes, and ask class what it is they like so much in the grape. (The sweet *juice.*) Ask for names of other similar kinds of fruits.
(*b*) *Pulpy Fruits.*—Sometimes the mass around the seeds is not so watery as in (*a*), and yet it is not so firm as in (*c*). It is not *juice*, nor yet *flesh*, but something between these two; we call stuff of that kind *pulp*, and fruits which have it, *pulpy*.	(*b*) Show class a strawberry, raspberry, and mulberry; and get the difference between these and the preceding. (Not so juicy; less liquid; more nearly *fleshy.*) Mash a boiled potato into a pulp with water, to show the meaning of the term "*pulp*".
(*c*) *Fleshy Fruits.*—These are still drier than (*a*) and (*b*), but not so dry as (*d*). We can *cut* these with a knife, and the fragments keep their shape.	(*c*) Show class an apple, pear, cherry, plum, peach or apricot. Try to squeeze the juice out of an apple or pear; and contrast their comparative dryness with the grape, or strawberry, in this respect.
Some of these are *stone-fruits*—that is, they have stones or kernels, or seeds in shells, inside, as in the cherry and plum. Others	Show class as many stone-fruits as can be got, either fresh, dried, or otherwise preserved, as Bosnian plums, etc. Cut an apple transversely to show the seed-

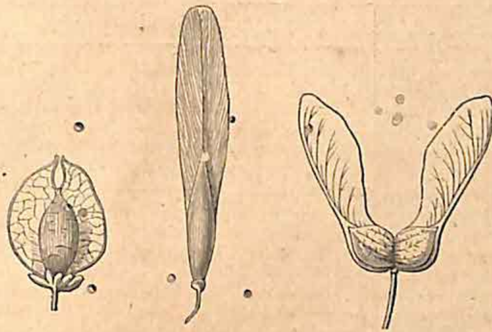
NOTES OF LESSONS—FRUIT—*Continued.*

Matter.	Method.
have pips inside chambers with skin linings to keep out the wet. (*d*) *Nuts.*—These fruits are the driest of all.	chambers, and tough skinny linings inside it. (*d*) Show class filbert, hazel, Brazil, Spanish, and cocoa nuts.
III. Useful Fruits— Fruits are *useful* to us, and to other *animals* for *food.* The most so are wheat (and other cereals). They are specially useful to *birds* (haws, cereals, seeds, fruits of weeds, etc.), and to *grazing animals* (eaten with hay, etc.); horses eat beans, sheep and pigs eat pease.	III. Enquire from the class what each of the fruits previously named (including the seeds), is used for, (*a*) By *man*; and (*b*) By other *animals.* Point out that the *dry* fruits (cereals) can be stored for winter use, and carried from one country to another.

63. NOTES OF LESSONS—SEEDS.

Apparatus.—Boxes of dried peas, beans (Windsor, scarlet-runners and French), wheat, barley, oats, rye, maize; mustard, cress, carraway, pepper, and linseed; also a poppy-head, pea-pod, bean-pod, wall-flower seedbox (siliqua); potato-apple, rose-hip, apple, vegetable marrow; dried Bosnian plum, currant, raisin, cherry; cotton-pod and seed, and nuts. Also burs, horse-chestnut in case, furze-pods, samara of ash, etc.

Matter.	Method.
I. What Seeds are— If we put *seeds* into moist ground, they grow into *plants.* So the seed is that part of the plant which produces the *future plant.* It is the little *baby* that is to grow up, and take the place of its parents. Or it goes out and finds a home and resting-place for itself. If new plants were not thus provided for, there would at last be no plants at all.	I. Prepare beforehand some *seedlings* of wheat, mustard, and cress, in water and in soil. Pull up one wheat plant, and show the *roots* (radicle) and *stem* (plumule) growing out of the grain. Ask children what other seeds their fathers sow in the garden (or in the field in the country). Encourage them to set for themselves, kidney beans, Windsor beans, peas, etc.
II. How they are Protected— None of the seeds mentioned above are left *naked*, any more than a baby is. We use clothes for the baby, to keep out the *wet* and *cold.* The seeds are *protected* from wet and cold also, by pods, pulp, juice, hard shells, chaff, hard skin, and by other means.	II. Enforce the beautiful lesson of the motherliness of *nature*, and goodness of *God*, in thus protecting the helpless; and His wisdom and goodness in the "*adaptation of means to ends*", in each separate instance. Show the inner, skinny, *lining* of the pea-pod which keeps out the *wet*; the pulpy flesh of the apple



(1) (2) (3)

Key-fruits:—(1) The Elm. (2) The Ash. (3) The Maple.

Double Pod.

NOTES OF LESSONS—SEEDS—*Continued.*

Matter.	Method.
If the seeds get *wet*, they would mostly begin to grow at once. And as they fall on the ground in autumn, it would not do for them to begin to grow at once, as the winter would kill the tender young plants. So they "go to sleep" all the winter in their warm, tight, snug, little *houses*. In the warm weather, the soft rains rot the shells, pods, etc., and the young seeds then begin to grow with the summer in front of them.	which will rot down, and form food for the sprouting pip—like the *feeding-bottle* put into the cradle along with the sleeping baby. Call attention to the provision of Nature, by which most young *animals* likewise begin life in spring, *e.g.*, chickens, ducks, birds generally, lambs, calves, etc. Point out the necessity and advantage of this arrangement to the animals themselves, and to man in the case of the *domestic* animals.
III. How they are Scattered— But there would not be *room* for all the young seedlings where their parents grow. They must go "out to work", and "get their own living". But they cannot "leave home" of themselves, like boys and girls. They "want carrying like a baby". So seeds are carried off from home by *winds*, and *waters*; by *animals* (birds, etc.). Some have *wings*, and "fly away", or rather let the winds fly away with them, as the ash. (*a*) Some have *claws* and cling to sheep, calves, cows, horses, and	III. Ask children what older brothers and sisters they have; and where they are working; and why they did not all stay with their parents. Point out that these could "forage" for themselves; but a higher power must do so in the case of the seeds. Enumerate in each instance the *fitness* of the means of transport (dissemination). Show a specimen in each case and point out the *means* as well as the *methods* of flight. Cultivate the *imagination* as well as the *observation* of the children by these

NOTES OF LESSONS—SEEDS—*Continued.*

Matter.	Method.
children passing by, as burs, horse-chestnuts, etc. (*b*) Others have feathery "*mop-heads*", light as air, and float off like balloons, as in the thistle-down. (*c*) Some have "*pop-guns*" and are shot out of their cases, as in furze seeds on a warm day "cracking off" at a great rate. (*d*) Others "*swim for their lives*", dropping into the water, by the side of which their parents grow, as in the willow. (*e*) Some are "*inside passengers*", with birds as their coaches, as stone-fruits, *with* stones for seeds, as in haws. (*f*) Many are transported by *man*, as those of the vegetable-marrow and cucumber.	child-like comparisons; and encourage the children to carry out the metaphors. Instead of "telling" the children the items of information in the "Matter" column, try to lead the children up to suggesting it themselves to the teacher. Keep in boxes a stock of the specimens named, so that they may be readily handled when wanted; and get as many of them as possible from the children themselves. Let the children bring out of the lanes, fields, and gardens *anything* of a vegetable nature that strikes their fancy; leaving it to the teacher to make what use and explanation of these he can. Encourage them also to make a little "Museum of Botany" of their own.

The remaining subjects in "Plants" are less difficult even to a young class teacher than the preceding, and will require no "Special Information for the Teacher", beyond the items set down in the "Notes of Lessons" themselves.

64. NOTES OF LESSONS—BARK.

Apparatus.—Corks, virgin cork, bark of various trees, green elder sapling, or willow slip.

Matter.	Method.
I. Introduction— One use of the stem is for the food to go up it from the roots to all parts of the plant. When this food or "*sap*" reaches the leaves it is made fit to nourish the plant. It then comes down again between the bark outside, and the wood inside, and is turned into bark and wood as it does so, making thin layers in each, as seen in the "*rings*" of wood in the one case, and the "*inner layers*" of bark on the other. Strip the green outside from a willow slip, to show they are distinct.	I. Ask children who has seen a standing tree that has been a long time *dead*. In what way was it different from one that was *alive*? (It had no leaves on it in summer.) In what *other* way was it different? Did the children notice anything about the *bark*? (No.) Well, one of the two trees had bark on it, and the other *not*. *Which* had *not* got bark? (The *dead* one.) Then get the class to see that *perhaps* this was the *reason* why the tree died: if so, it shows that bark is necessary to the tree.

NOTES OF LESSONS—BARK—*Continued.*

Matter.	Method.
II. Parts and their Uses— The bark is made up of an *outside* and an *inside* portion. The *outer* is very different in thickness, colour, roughness, etc., in different trees. The *inside* layers are very tough, and it is here that the tree grows in thickness. The food, or moisture from the roots, comes up this layer, to the leaves and to all other parts of the tree. This is like our food being altered in the stomach, and sent to feed all parts of our bodies, the blood being our body-food, and the sap that of the plant.	II. Now *strip* off the bark from a growing elder sapling, in spring. Ask class to notice how easily, and smoothly, it comes off. Ask what this outside covering is like in an animal. (The *skin.*) Divide the green freshly-stripped bark of a tree into its *two layers* and show these separately to the class. Let the class see how *moist* the inside of the bark next the wood is; and ask where this moisture, or "sap" came from (The *roots*); and what is the *food* of the tree. (The "*sap*".)
It is therefore very important not to hurt or destroy this inside layer of the bark of trees. So we take great care in public parks to preserve the bark from being wounded, by placing fences round trees in parks and streets where cows and deer are kept, and where people are constantly passing by.	Enquire from the children how *animals* are kept off from *young* growing trees: and why we remove these railings when the tree is *old.*
These two layers of bark are like our outer and inner *skin*, only the outer and inner layers of bark are really made up of many thinner layers. But in both cases the outer layer is *dead.* So this skin in our bodies can be cut, and in trees it can be removed, as in the cork tree.	Show, if possible, the *outer skin* of our body, by referring to any child having a *blister* on it. Otherwise, ask the first child who has one at a future time to come and show it to the teacher, and *then* make use of this as an illustration of the outer layer of *bark* on trees.
In flax and hemp plants the inside bark gives us fibres or threads for weaving. The outer bark of the oak-tree, etc., is used for tanning raw hides into leather.	Show class stems of *flax* and *hemp*, and the fibres got out of them. The former can be grown in a pot in the school, from linseed. Show children some "*tan-bark*" from a tan-yard, and also a piece of Spanish "*virgin-cork*" used for ornamental garden purposes.
III. Cork— *Cork* is the bark of a kind of oak-tree which grows in another country, and which we bring over to England. It is first stripped when the tree is about as old as a young man; and again about every ten years after. The first stripping gives us a very coarse kind of cork-	III. Explain to the children the separation of this *cork* from the stem, by making circular and vertical incisions in a growing twig, and by stripping off the green bark or skin thus cut from a young sapling (elder, willow, etc.). Compare with raising a blister of the outside skin. Flatten these out, by pressure, before

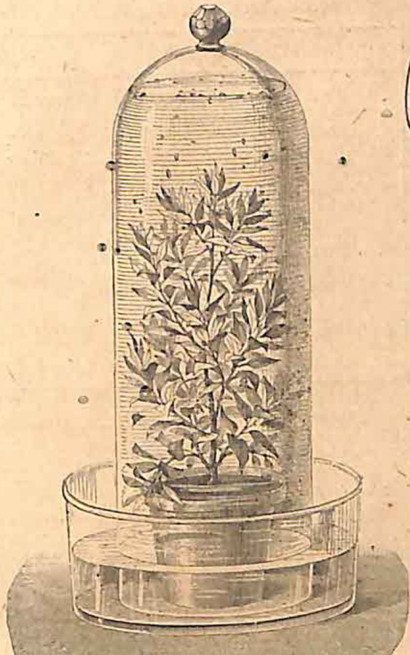
NOTES OF LESSONS—BARK—*Continued.*

Matter.	Method.
bark used for holding on the window-sill the pots of window-plants, etc. The bark is stripped off by cutting it *round* and *down* the tree. The outside is scraped, cleaned, and pressed to flatten it out. Cork is used to make a kind of floor-cloth, and for bottle stoppers, soles of boots, buoys, etc.	the class, to illustrate similar treatment of cork. Show class a strip of *linoleum*, partly made out of cork; and point out how like it is to cork in *lightness*, *toughness*, and resistance to *wet*. Point out to the class that if the *inner* layers of bark were thus stripped from trees they would die.

65. NOTES OF LESSONS—HOW PLANTS GROW.

Apparatus.—*Plants* growing in pots. Hyacinth *bulbs* growing in water. *Seeds* sprouting on damp soil. Plant previously severed from root.

Matter.	Method.
I. That Plants do Grow— When we go into a wheat field in early *spring*, the wheat plant is only a few *inches* high; at *harvest* time it is several *feet* long. Again, a little seedling from an *acorn* becomes a great *oak*. Where, moreover, it is bare ground in winter, there may be a heavy crop of turnips, mangolds, etc., later on. So plants *grow*, or *become larger* with time.	I. The teacher should have previously set in loops or saddles seeds of mustard, and cress; the top or "crown" of a carrot, turnip or parsnip, in bottle of water; linseed; to show the increase of size due to growth. Ask children what they have seen "growing" in the fields, or garden, or in flower-pots, to make them sure that there is such a thing as growth and increase of size in plants. Compare with similar growth in animals and specially in children.
II. How Plants Grow— All these young *plants* were like the young of the lower *animals*, and specially like babies. The baby also grows bigger and bigger. But we could stop it growing if we liked, by not giving it any *food*. So, perhaps, it is *eating* and *drinking food* that makes the *plant* grow too. The plant sucks up ("drinks") water through its tiny little "*mouths*" at the ends of its roots. This water at the roots is not clear, clean water; there is in it something else. When we pour water on the ground it be-	II. Enquire what *domestic animals* the children keep, that show *growth*; pig, horse, calf, kitten, chicken, lamb, etc. Get from the class that these all require *feeding*. Next enquire what *house* or *window-plants* are kept; and show that these also require feeding (with water). Just as a baby has a "feeding-bottle", and drinks *milk*, so plants drink *water*. But we sometimes put *sugar* into the milk and it "melts"; then the baby drinks the sugar, too. So the water we give to the plant "melts" things in the ground, and the plant "drinks" up these too. Pour some clean water into a flower-pot



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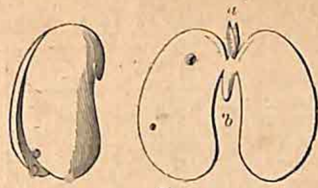

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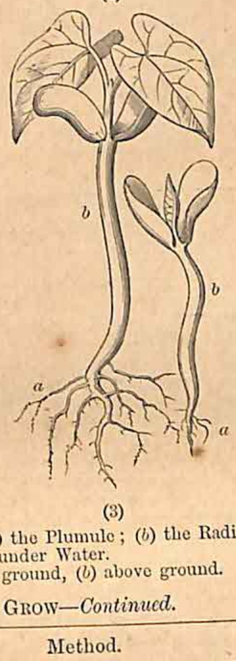


(3)

(1) Beans with their Seed-leaves opening out: (*a*) the Plumule; (*b*) the Radicle.
(2) Disengagement of Oxygen under Water.
(3) Germination of the Bean Plant: (*a*) below ground, (*b*) above ground.

NOTES OF LESSONS—HOW PLANTS GROW—*Continued.*

Matter.	Method.
comes *muddy*. So the water "melts" some of the ground or *soil*, and this goes into the roots of the plants, and climbs up the stem like a "Jack-of-the-Beanstalk"; only by the *inside* of the stem not the outside as Jack climbed. And it goes up and feeds the baby *leaf-buds* and *flower-buds*, and makes these grow into green fleshy *leaves*, and bright *flowers*. Part of the plant's food comes out of the *air*, since the plant breathes through its leaves, just	full of earth, and show the class the dirty water that runs out into the saucer. Show class that in a bottle, a seedling (of wheat, flax, etc.) will not continue to grow in *water only*. It at last wants *soil*. Compare two such, one grown in water and earth respectively. So also the baby at last has to eat *solid* food, as well as drink liquids. Get from the children *when* father sows his seeds. (In spring or summer.) And what makes the fields look so bare in winter, after the corn has been carried, and the turnips (swedes) and mangolds have been carted away.

NOTES OF LESSONS—HOW PLANTS GROW—*Continued.*

Matter.	Method.
as the baby, too, has to breathe, and get part of its food out of the air. Seeds and plants also require *heat* to make them grow. In winter time seeds will not sprout, and hardly any plants then increase in size. They get their heat from the sun, or from fires in hot-houses. But they get something else from the sun besides heat: for window-plants turn to the *light*. This shows that they require light as well as heat.	Get from the class all the things required for plant growth— (1) Air. (3) Soil. (2) Water. (4) Heat. (5) Light.

MAMMALS.

The next department of Natural History taken in this Standard is Zoology, as represented in this early stage by the higher "**Classes**" of animals; and by well-known **types**, selected from domestic **Mammals**, etc. These preliminary outlines will be filled in and supplemented by other groups in the Animal Kingdom in Standard III. The present mode of attack is intermediate between the previous Infant School treatment of these animals, and the later and more scientific handling of the subject.

66. NOTES OF LESSONS—CATS AND THE CAT-TRIBE.

Apparatus.—A live cat; pictures of lion, tiger, and especially of their heads and teeth; and their feet and claws.

Matter.	Method.
I. Introduction— *The Cat.*—(*a*) This is found in most houses, and is a great favourite. It is affectionate, and useful against rats and mice, especially against the latter. The leopard and tiger are similar in *shape*, *habits*, and *build*; but larger in *size*. As we divide school-children into standards, so we call these animals the cat-"tribe", or cat-	I. (*a*) Ask where else the cat is found. (On mountains, in woods, etc.) What sort of cat is this? (Wild.) What is the great difference between wild and tame cats? (One is *domesticated* and gentle; the other not.) Ask the class to notice how still a cat sits, until a mouse is in a favourable situation for capture. Refer to diagrams to show the likeness to cats in the leopard and tiger, in their

(1)

(2)

(3)

(4)

(1, 2) Cat's Head, showing pupils closed and open. (3) Foot, with claws unsheathed. (4) Foot, showing cushions or pads.

NOTES OF LESSONS—CATS AND THE CAT-TRIBE—*Continued.*

Matter.	Method.
"*family*". The likeness in all these depends on the similar shape and build and use of the *head, teeth, claws,* etc. These again depend on the nature and mode of capture of their *living prey*, as the teeth and claws are used to seize and hold this.	build and shape, and in their teeth and claws. Remind the class that in a similar way the dog, wolf, and fox are very like each other, and also like the horse, mule, and ass.
II. Food— *Cats* eat raw flesh, mice (rarely rats), fish, and birds. *Tigers* eat raw flesh as their living prey. Hence these animals, among others, are called *beasts of prey*, or flesh-eaters (*carnivora*). They are very different in their teeth, claws, etc., from cows, sheep, and other vegetable-feeders (*ruminants*).	II. Give word-picture of the way in which a cat watches birds on trees, and awaits the right moment to steal fish, etc. Some cats like fish so much, that they will even enter water for them. Tigers, being larger and stronger than cats, attack larger animals, such as the deer, buffalo, etc.

NOTES OF LESSONS—CATS AND THE CAT-TRIBE—*Continued.*

Matter.	Method.
III. How Food is Obtained— (*a*) The cat must first *see* its prey. It patiently watches and waits for it. It is chiefly obtained in the dusk; hence the cat's *eyesight* is keen. The *pupil* enlarges as the light lessens, to let more light into the eye; thus the cat-tribe can see, when many other animals cannot. The *curtain* of the pupil, on the other hand, contracts in a bright light, the pupil then becoming only a narrow *upright* slit. The curtain is like a window-blind that lets in or shuts out the light.	III. (*a*) Draw a diagram of the pupil of *human* eye. Contrast our *round* opening, with the *vertical* one of the cat, and the *horizontal* one of grazing animals. Show by an india-rubber ring how the *pupil* is *opened*, and *closed*. Also show (if a live cat is present) the same, by cutting off some of the light from entering a cat's eye. This enables the cat, etc., to see so well in the dark, and to look *up* into trees for birds, and *down* on the ground for mice, etc.
(*b*) *Cats walk or creep noiselessly*, obtaining their prey by stealth. The feet have *pads*, or cushions, on those bones on which the animal rests whilst walking. Cats walk on their *toes*, like a boy entering a room silently. This silence is very different from the noise made by a *hoofed* animal, as the horse.	(*b*) Why must the cat-tribe walk noiselessly? (Because they do not outrun their prey, like the dog.) Show these soft cushions in diagrams, or on the foot of the cat. What other use have these cushions? (To help to break shock when jumping.) Further illustrate by felt slippers, buffers on railway carriages, and by tying a duster on a boy's boot.
(*c*) *Cats spring* on their prey. The *legs* are strong and muscular; the *body* slender, not heavy like the elephant's; and they have no heavy hoofs like the horse. The *pads* are elastic.	(*c*) Relate anecdote bearing on the *spring* of the lion or tiger, and show that cats can similarly leap from walls, etc., on their prey, such as sparrows and mice.
(*d*) They seize prey with their *claws*, not with teeth. The claws are curved, sharp, with strong muscles, very strong to pierce, and hold prey firmly, and to kill it. The claws are so made, that the act of striking throws them forward. Being so necessary, they are preserved in *sheaths*. The arms, fingers, and nails, of a child correspond to the forelegs, paws, and claws of the cat. But our fingers and hands are better grown than our toes and feet. Cats can climb trees with their claws.	(*d*) Let children see and examine the foot of a live cat, and feel that the claws are sharp. Why are claws kept in sheaths? (To keep them sharp. If not in sheaths they would become blunt.) Refer class to tigers in a menagerie and museum, for the examination of claws. How could we make a cat throw out its claws? (By teasing it.) Connect this item with the succeeding one by reference to beaks and talons, in birds-of-prey, such as the eagle, etc., where the beak stands for the teeth, and the talons for the claws of the beast-of-prey.
(*e*) They *tear* their food. We cut, and chew ours. The cat's *teeth* are suited to *holding*, *cutting* and *tearing* food. This is swallowed in lumps, not ground down, nor chewed.	(*e*) Draw an enlarged diagram of cat's *tooth* (*canine*); and show how adapted it is to *hold* and *tear* flesh; and why bent *backwards*.

NOTES OF LESSONS—CATS AND THE CAT-TRIBE—*Continued.*

Matter.	Method.
Children also have "*cutting*" teeth, next the "*grinders*". The cat's tearing teeth are bent back, and are at the corners of the mouth. The teeth behind are not broad and flat on the crown like ours, but sharp, and overlap like the blades of scissors, or shears. The jaws, too, move up and down like these; not from side to side as in the cow.	We also swallow our food in small lumps or balls; but only after it has been well chewed. Let the children move their jaws to see the action of *grinding*. Show picture of the head of the tiger, to illustrate the tearing teeth, which are there very largely developed. The flesh of the prey has to be torn and cut, rather than ground down as in a mill as it is in grazing animals, in beasts-of-prey.
(*f*) In the dusk cats have to *feel their way* to their prey. They must then judge the size of a passage, so as to creep through it without noise. *Whiskers*, therefore are provided as *organs of touch*. The body is lithe, slender, and fitted for creeping through narrow openings. It is similar in this respect to those of rats, mice, rabbits, ferrets, weasels, and other animals living underground.	(*f*) Where are the whiskers placed? (At the sides of the snout.) Show a diagram of these, or refer to them in the live cat. They are always straight out. What does the cat do with them? (Feels the way in the dark.) They also tell the cat if it can creep through a passage; for if it can get the head and whiskers through, it can do so with the rest of the body. Tigers also have whiskers.
(*g*) *Cats scrape bones clean*, with a tongue rough like a file or rasp; and they lap water with it.	(*g*) Let children feel their own, and then a cat's tongue, to detect the roughness of the latter.
IV. Structure— (*a*) *Head*.—This is roundish, the muzzle and jaws both short and round, with strong muscles for holding living prey. (*b*) The *ears* are long, and prominent, and pointed. (*c*) The *eyes* are large and round.	IV. Show a cat in school, and illustrate these points on the living animal, getting these characteristics or distinctive marks through the observation of the children themselves.
V. Covering— The *covering* is of various *colours*. All have soft *fur*, which they like stroked from the head to the tail. All mammals (except whales, living in water) have for covering, *hair*, *fur*, or *wool*. They are thus sharply distinguished from *birds* with feathers, and from *fish* with *scales*.	V. Ask for different colours and varieties of cats. Contrast the colours of cats with those of tigers. Why are cats covered with fur? (For warmth.) Would hair, like the dog's, be as warm? (No.) Notice long tail. Point out that the lion has a mane, but the cat has not.
VI. Sounds— A child utters different sounds according to its feelings; it laughs, cries, groans, etc. So a cat *purrs*, *mews*, *growls*, and "*spits*". When pleased it rubs its head against our legs.	VI. Ask what moods or tempers the child and cat are in while uttering these different sounds. If possible, induce these different moods in a live cat, to better illustrate this point to the class.

NOTES OF LESSONS—CATS AND THE CAT-TRIBE—*Continued.*

Matter.	Method.
VII. Classification— Cats belong to the *back-boned* animals; and to those having *warm blood*, and which *suckle* their young; and to those that are *flesh-eaters*. [These items will give *vertebrates*, *mammals*, and *carnivora*.]	VII. Ask children to feel the strong *backbone*, and *warm* flesh of a live cat; and enquire what cats and kittens like to drink. (*Milk.*) But do not press the latter point any further.

67. NOTES OF LESSONS—DOGS AND THE DOG-TRIBE.

Apparatus.—Diagrams and pictures of different varieties of dogs, the wolf, and fox; specially of their heads and teeth; and their feet and claws.

Matter.	Method.
I. Introduction— Like the cat, the dog is a *domestic* animal, fond of man, and often his companion in the chase. As many animals are like the dog in appearance, build, habit, etc., we have a dog-"tribe", including the wolf, fox, jackal, etc.	I. Show pictures of the dog and cat, and compare and contrast their shapes. Also show pictures of fox, wolf, etc., for the same purpose. Relate some anecdote of the dog's love of his master; or point out its fidelity in minding its master's property, etc.
II. Food— All these are flesh-eaters (*carnivora*), and feed on *living* animals. The wild dog preys upon rabbits, hares, foxes, deer, etc. The house-dog, etc., eats flesh brought to it. The build and structure of the dog are fitted for obtaining flesh for prey, specially in the legs and the teeth.	II. As dogs feed on flesh, what kind of teeth should they have? (Strong tearing teeth.) In some countries there are *wild* dogs, and these have still larger tearing teeth than our domesticated dogs. Draw a diagram of a (canine) tooth on blackboard, to show how *long* and *pointed* it is, and compare with a lion's (in a picture).
III. How Food is obtained— (*a*) Some dogs, as the greyhound, hunt by *sight*. Unlike the cat, the dog does not depend on stealth, or cunning; but only chases its prey. Hence its *eyes* differ from a cat's. The *pupil* is round, not a long, narrow slit. Like a child's, it can adapt itself to different degrees of light; but not open out so much as a cat's.	III. (*a*) Show a picture of a greyhound; and point out how it is fitted for hunting. What kind of *eyes* must greyhounds have? (Very sharp and keen.) Refer to a child's eyes, to illustrate the dog's pupil. Draw a diagram showing the difference between the pupils of the eyes of a cat and a dog. In very strong light what do the pupils of a child's eyes do? (Become smaller.)

NOTES OF LESSONS—DOGS AND THE DOG-TRIBE—*Continued.*

Matter.	Method.
(*b*) Others, as the blood-hound, foxhound, harrier, etc., hunt by *scent*. Hence their nostrils are prominent; and the head long to allow room for this.	(*b*) Show a picture of one of these dogs, and point out the difference from the greyhound in the shape of the head, and in the heavier body. Ask for various *uses* of these breeds of dogs.
(*c*) Dogs seize their prey with their *teeth*, not with their *claws*. Hence the latter are not so strong as in a cat; nor so strong as their own teeth and jaws. Where they dig or scratch for food (rabbits, or foxes in holes), the claws are short, stout, rather blunt, not easily broken, and grow rapidly, as they wear out rapidly also in running, and in scratching, or digging up the soil. The claws are sharp and strong, as in the birds called "Scratchers" (hens, etc.).	(*c*) Draw a diagram of a dog's *foot*; and compare it with a cat's. Let the children feel, in a live dog, that the *claws* are dull, not sharp like the cat's; and notice the five toes on the fore feet, and the four on the hind feet. Why cannot a dog put his claws or nails out of sight like a cat? (Because it has no *sheath*: the claws are fixed, like our nails.) How is it they are so short, and yet always growing? (Constant use wears them away, as with our boots.)
(*d*) Dogs hunt for prey *openly*; not stealthily like the cat. Hence their feet are not noiseless. The claws stick out, and always touch the ground; and are not so much bent as the cat's, not being used for climbing. They are also shorter, blunter, and not drawn back into a sheath. They grow rapidly to repair wearing away in walking.	(*d*) Refer children to their going into strange premises, and the dog springing out of kennel, not lying in wait for them. Refer to a diagram, and notice that the cushions are not so marked in a dog's feet as in the cat's. Get from the class that dogs dig into the ground, with claws and feet, for rats, rabbits, etc.
(*e*) Dogs *tear* their food. The *teeth* are sharp to cut, and pointed to hold and tear. Little grinding is required, so there are no flat-crowned, double-teeth, like the cow's. The *jaws* move up and down; not sideways as in grazing animals (Ruminants). Note, as in cat, the big teeth for seizing and tearing are at the corners of the mouth, and are curved for holding their prey.	(*e*) How is food swallowed? (Bolted in lumps). Ask children to notice their dog feeding at home; how quickly a large dishful of food disappears. Also notice that a dog is not so particular as to cleanliness as the cat. Which way do the tearing teeth bend? (Backwards.) Why? (To keep their hold on their struggling living prey, rabbits, hares, etc.)
(*f*) *Drinking.*—The *tongue* is soft, and used for lapping water. The dog never perspires through the skin. Moisture is got rid of from the tongue, not through the skin as with us. Hence a dog's running with the tongue out; and the moisture seen in its *mouth*.	(*f*) Let children feel the rough tongue of a dog. When the dog laps water, what shape does its tongue take? (That of a spoon.) How does it get the water into its mouth? (By jerks of the head backward, throwing the water down the throat.)

NOTES OF LESSONS—DOGS AND THE DOG-TRIBE—*Continued.*

Matter.	Method.
IV. Build— This differs according to habit. (*a*) The *head.*—The *Greyhound* hunts by *sight*, so has prominent eyes, long head, and narrow snout. The *Foxhound* hunts by *scent*, so has prominent nostrils, long and broad; with eyes bold and prominent. The *St. Bernard*, and *Sheep-dog*, etc., are intelligent, and have a well-developed brain, and a broad massive head, and are often used for saving life. *Pet dogs* generally have small heads, and ears generally developed according to fancy or demand. (*b*) *Ears.*—These are prominent, overlapping, and pricked up when roused. The hearing is acute. (*c*) *Body.*—(1) *Swift* dogs, as the greyhound, have a slight build, long thin legs, and a tail long and curved. The foxhound is stronger in build, as it runs longer than the greyhound, and has more lung space, so has greater breadth of chest. (2) Dogs of *endurance*, as St. Bernard, Newfoundland, sheep-dog, bloodhound, etc., have a massive body, legs, and frame; and generally dogs are not so lithe as the cat-tribe.	IV. (*a*) Show in a live dog, how easily it can move its head in all directions. Let the children see that whatever organ is most *used*, is most highly *developed*. Illustrate this by reference to different trades: a blacksmith generally has very strong *arms*, etc. Show by diagrams, that a boy's head is broad, like that of an intelligent dog. Illustrate the dog's intelligence by an anecdote. Show pictures of all the varieties of dogs mentioned, and point out on them the characteristics mentioned. Do this by way of question and answer, to make the pictures *self-interpreting.* (*b*) What is the difference between a boy's and a dog's ears? (The dog's hang down generally, the boy's are erect.) (*c*) (1) By pictures show differences in the build of different breeds. What are the different breeds used for? Why do dogs that run much require large lungs? (To give them plenty of air-space for breathing.) (2) Relate an anecdote of dog's *endurance* and *strength*; and show that the build of each variety is suited to its habits. Contrast the body of the cat and of the dog.
V. Covering— This is *hair*; and is not so soft as the cat's fur. It varies according to the breed or kind. It is thick in the collie, curly in the retriever, long in the Newfoundland, long or short in the terrier (two kinds).	V. Compare the *covering* of greyhound, retriever, terrier, and collie. Notice that a dog's "coat" looks better when nicely washed. Point out that the dog is not so cleanly with its skin as the cat.
VI. Sounds— The dog *barks, growls, whines*, etc., to express, like children, different feelings. It expresses pleasure by wagging its tail, and by moving its ears.	VI. What *moods* would a dog be in when whining, growling, and barking? Notice the moving tail and ears of a dog when let loose to go for a walk with its master.
VII. Wild Relations— These include the wolf, the fox, and jackal.	VII. Show class pictures of each of these animals.

THE CAT AND DOG COMPARED.

A. Cat.	B. Dog.
I. Size— Compare with that of *small* breeds of dogs.	I. Variable. Contrast a St. Bernard and a Skye-terrier dog.
II. Covering— Fine fur, with over-hair, which prevents felting. The overhair is stiff, and straight; the colour, black, white, tortoise-shell, tabby, sandy, etc.	II. Dog's hair is coarser than cat's fur; it is varied in colour, texture, length, etc., smooth, rough; curly, straight; soft, wiry. (Contrast in common breeds.)
III. Shape— Long, slender, able to pass easily among bushes and down small passages, and into little openings in search of its living prey. Compare and contrast with lion and tiger, for shape of body; and with the stiffer, stronger build of the dog.	III. *Greyhound.*—Long head, narrow snout, hunts by sight; limbs slight for speed. *Collie* and *Newfoundland*—Heavier, speed not being required; intelligent, hence large heads. Chest deep when speed and endurance are required. Those chasing by scent have broad muzzles.
IV. Claws— Curved, strong, sharp, for *seizing* and *retaining* prey, and for *climbing* trees and walls. Can be drawn back (*retractile*); hidden in *sheaths* when not in use, to keep them sharp.	IV. Cannot be drawn back (*non-retractile*); short, blunt, straight; *not* used to *seize* the prey, nor for climbing. They touch the ground in walking; and grow fast, as they wear out in walking on the hard ground.
V. Defensive Weapons— *Teeth* and *claws* are the natural weapons of the cat.	V. The canine teeth are principally used as weapons of defence and offence.
VI. Jaws— The jaws move up and down (vertically) only, not to and fro (laterally) as in Ruminants.	VI. The jaws move vertically only; not laterally as with grazing animals: and are thus like the cat's.
VII. Teeth— Adapted for *cutting*, *tearing*, and *holding* prey, not for grinding. Three kinds, all sharp, for above purposes. (*a*) *Incisors*, (*b*) *Canines*, (*c*) *Molars*, suited to cut flesh and split bones; working like blades of scissors.	VII. Similar to cat's. Note that the food is generally alive, but the dog sometimes takes this both alive and dead. The teeth are stronger than those of the cat, specially those used for splitting bones to get at the marrow. Dogs also *eat* bones more than cats do.
VIII. Nose— This is not particularly required for scent, so is not prominent.	VIII. In dogs hunting by scent there are large organs of smell. In others the

NOTES OF LESSONS—THE CAT AND DOG COMPARED—*Continued.*

A. Cat.	B. Dog.
Cats depend rather on lying in wait for their prey, than on running it down by sight or scent.	snout is pointed (as in the greyhound); the nose must be prominent. It is cold and wet, whereas the cat's is dry.
IX. Eyes— These are large and round; the cat preys chiefly at night, so the pupils are adapted to varying light. Compare the position of the eyes with a horse's, and a child's.	IX. Point out that the dog's eyes are not shielded by curtain as in the cat's. The eyes are better suited to daylight than to dark. In dogs hunting by sight, the eyes are clear and prominent, as in the greyhound.
X. Ears— These are large, prominent, and movable. The cat's hearing is very acute, as it does not run down its prey, but awaits it in stealth.	X. These vary in size, shape, etc., according to breeds; being long and bent over, short and pointed, etc. They are movable separately to express feelings. The hearing is acute.
XI. Tail— This is long, thick, and hairy. Erect and stiff when pleased; lashed from side to side in anger, as in some wild beasts of prey.	XI. The tail varies in size and character. It is used to express pleasure by "wagging". Compare collie and terrier. The tail keeps the paws and nose warm, in sleep.
XII. Sound— The cat *purrs* (to express pleasure and happiness); *mews* (for food, and in pain); *growls* (when teased); and *spits* (when angry).	XII. The dog *barks* (for joy, or to give alarm); and *whines* (in fright, pain, and hunger).
XIII. Locomotion— The cat walks on the toes quietly; and has pads to the bones of the feet. The foot is like another leg-joint. In the fore-leg bone, near the body, is the first joint (elbow); the next corresponds with our wrist. Hence cats spring silently on their prey.	XIII. The dog walks on its toes. Some kinds have great speed, and can leap. The feet are padded. The build of the legs is adapted for speed and springing. Dogs have great strength and endurance in walking, so are used for draught in Holland and by the Eskimos. (Show picture.)
XIV. Modes of Feeding— The cat seizes, holds, and tears its food with its *claws*; and swallows it without chewing, as other beasts of prey do. It laps water, milk, etc., with the tongue. It is *more domesticated* in its food than the dog, from long association with man. It is also *more cleanly* in its feeding than the dog.	XIV. The dog seizes and tears its food with its *teeth* (canine); but holds it with its paws. It swallows it in lumps, when first divided by incisors and molars. It splits bones to get at their marrow. It can digest broken bones as well as flesh. It laps water with its tongue like the cat. It hunts down its prey, instead of pouncing on it from ambush.

NOTES OF LESSONS—THE CAT AND DOG COMPARED—*Continued.*

A. Cat.	B. Dog.
XV. Uses— The cat destroys *vermin* (mice, etc.), and sometimes game and rabbits also. It is kept as a *pet.* It is not so useful as the dog, and is less widely distributed, but more domesticated. It is never used for draught, protection, or sport of man.	XV. The dog is used for *sport.* Greyhound, foxhound, etc., in the chase; the pointer in shooting. To *shepherd*; as in the collie. For *protection*; as in mastiff. The *Newfoundland*; as a water-dog. The *terrier* destroys vermin, generally rats.

68. THE TIGER.

INTRODUCTORY SPECIMEN LESSON.

I. The Cat-Tribe.—(*a*) The tiger belongs to the cat-tribe of animals; and we can see the likeness between the cat and the tiger in the general build of the body, which is long in both, and more crouching than in the lion.

(*b*) The tiger, like the cat, keeps its claws within its sheaths, until it is ready to spring upon its prey.

(*c*) It also prowls about by night, with a stealthy tread, and feeds on flesh.

II. Habits of the Tiger.—There is something very dreadful in the look of a tiger; even if it be shut up safe in a cage. It is crafty and cunning; not like the open-faced, fierce, but honest-looking lion. In its native forests it is, of course, far more stealthy. It will spring out upon one without warning; and with one blow of its heavy paw strike one to the earth; and then drag him to its den, or to the wild bushes (jungle), to make a meal in safety. A great many people lose their lives every year in this way where tigers abound.

III. A Tiger Hunt.—Englishmen are very fond of joining in a tiger-hunt; they like the danger there is in this sport. A party start off for the place where the tiger has been known to be prowling about; some riding on elephants, others going on foot. They carry guns and pistols; and track the tiger, if they can do so, to his den.

The elephants throw up their trunks out of the danger of being seized by the tiger when he is made angry by the chase. The

hunters fire upon the wild beast from "castles" on the elephant's back. But sometimes a man is dragged by the tiger from the back of the elephant, and carried off into the bush. Or, the tiger pounces upon some one of the hunters closing round him; and, before a shot can be fired to save him, the poor man is torn to pieces. In a tiger-hunt the animal will sometimes seize a man by the arm, and throw him over his back like a cat would a rat, or as a dog would do to a rabbit. The tiger's teeth meet in the man's flesh, and cause great pain; while the loss of blood is so great as to make the man faint.

The tiger is very strong in the **jaws** and **paws** (as are most beasts of prey), and can drag an ox along the ground, and leap over fences with smaller prey, as well as strike very large prey down at its feet at a blow, so it easily kills the hunter if it gets him into its power.

It is very fond of **prowling** about villages, to carry off men, and the domestic animals which men keep in folds and pastures, such as sheep, calves, and cows. So the natives of these parts kill it with arrows which they have previously dipped in poison. Or, they hang beams of timber in its path near a bait, such as a dead or live animal. When a tiger springs upon this, it is caught by the cords from which the beams hang. Then the great beams fall down, and crush the life out of its body.

IV. Colour.—The **colour** of the tiger is a bright orange or yellow, with white on the under part of the body and throat, all crossed by stripes of jet black. The beautiful **skin** is used for carriages and rugs; and people who have shot a tiger are very proud of having the skin.

V. Where Found.—The "**royal tiger**" is found only in a part of the great country called India; and the tiger generally is never found in any other but hot countries.

VI. Teeth.—The tiger's mouth has two very long dog-teeth in the upper, and two in the lower jaw. These teeth are much longer than the others, and reach quite over them in the jaws both above and below. They catch, and keep hold of, the living prey, when it struggles to get free again.

The rest of the teeth, at the back of the mouth, have sharp edges, like **scissors,** to cut and tear flesh to pieces, and to crush bones. It has no flat-topped grinding teeth like a horse or a sheep has, to grind its food, for it does not live on corn, hay, or other kinds of food that want chewing to a soft mass; but bolts its food, or swallows it in large pieces.

By the shape of the teeth we can tell what kind of food an animal lives on. All beasts of prey have sharp cutting edges to their teeth; while all animals that graze have grinding teeth.

69. NOTES OF LESSONS—THE HORSE.

Apparatus.—Horsehair, horse-shoe, molar tooth of horse; pictures of varieties of horses (hunters, etc.), and of ass, mule, and zebra.

Matter.	Method.
I. Introduction— We have already dealt with some *domestic* animals, and their *wild* relations:—(*a*) The leopard and tiger; (*b*) The wolf and fox. The *horse* is also a domestic animal. The former were *flesh-eaters*; the horse is not: the former sought their own prey, the horse does not in a domestic state. It is fitted to work for man, leading to marked differences in build, habits, etc.	I. Recapitulate the chief points of the previous two lessons on diagrams and pictures. Show the great differences in form and size between the cat, and the dog, and the horse. What kind of *teeth* does the horse need? (*Grinders.*) Show pictures of different breeds; and point out their chief differences, and enquire the work done for man by the different kinds. As with dogs, some horses are *swift*; others have *strength* and *endurance*.
II. Size— Horses are much larger than cats and dogs; being generally seven feet long, and nearly as tall as a man.	II. Compare this size with a child's, with the teacher's, or with objects in the school-room.
III. Parts of Body— (*a*) *Legs.*—(1) *Strong* and *stout*; most so in dray and cart-horses. The legs are strong, but less heavy, in hunters and racers, which are more used for speed. (2) The legs are *upright*, to bear the heavy weight of the body. The horse does not creep for its food; but its feet are used on rough roads. In hauling, and climbing a hill, its feet must "bite" the road; so strong iron shoes are used to preserve the hoof. (3) The *hoof* can be cut without hurting; as with the nails of a child. We must not cut into "the quick" in either case. The hoof grows rapidly, like our nails and the claws of a dog. Contrast the solid, *undivided* hoof of the	III. (*a*) (1) Show diagrams of cart-horse's and hunter's *legs*. Notice the great difference in their stoutness. Contrast their speed. Point out that a race-horse is built on still finer lines than a hunter. (2) Point out the differences of shape in the horse's fore and hind-legs. What advantage is there in a hoof that does not feel? (It is suited to hard and rough roads, can have nails put into its shoes, etc.) Show a horse-shoe, and its provision for "biting" on a hard road, and on ice. (3) How is it we can cut the hoof without hurting the horse? (There are no nerves in the hoof.) Show from a drawing the "frog", and the "quick" in it. This part has nerves, and so can feel. Sometimes on rough roads, a driver has to take a stone out of the "frog". Point

NOTES OF LESSONS—THE HORSE—*Continued.*

Matter.	Method.
horse, with the cloven hoof of the cow and the pig which move about on softer ground, which is less firm and gives way in wet weather more than a hard road.	out from drawings the difference of a horse's and a cat's legs. (One has *claws*, and the other *hoofs*.)
(*b*) *Chest.*—This is very broad and massive in the cart-horse; less so in hunters and racers, but deep to give large lung space. In all horses the lungs are large, and strong; and so the owners are strong in "wind as well as in limb", that is, they are well suited for *running* and *pulling*.	(*b*) Show in a picture the massive shoulders and hind-legs of a cart-horse for pulling purposes (hauling, or "draught"). Why is great lung space needed? (For sustained breathing in a swift course.) Remind boys who run a great deal that they enlarge their lung capacity.
(*c*) *Head.*—This is broad, as in many dogs. Most horses are very intelligent, the racehorse less so, and with narrower head.	(*c*) Relate an anecdote of the intelligence of the horse, and of the horse's ability to understand a kind driver.
(*d*) *Eyes.*—These are keen, and can see sideways, as well as in front. Most horses at work wear "*blinkers*". The horse sees in a dim light not by widening the pupil, but by means of a green colouring matter in the eyes.	(*d*) Compare with child's eyes as to their position. Show the advantage of this. Why do they wear "*blinkers*"? (To keep their attention directed in *front.*) Refer back to the eye of the cat and the dog, and show their means of regulating the amount of light.
(*e*) *Teeth.*—These differ from the cat's and dog's. Beans, oats, and corn require *grinding*; hence strong, flat-crowned "*molar*" or grinding teeth are provided, like a child's back teeth, and the motion of the jaws is *sideways* as well as *up and down*. The front teeth ("incisors") are sharp, like ours, for biting off grass, etc. The number of the teeth in the "*Dental Formula*" in each quadrant of the jaw is $\dfrac{3 \quad 1 \quad 3}{\text{i.} \quad \text{c.} \quad \text{m.}}$ where i. means cutters (incisors), c. means canine, and m. means grinders (molars). The *bit* is placed in the space before the grinders. The *age* is told by the teeth. Certain teeth grow at a certain age, as with us, and marks also appear in them at different ages.	(*e*) Let a child feel its own "*cutters*" and "*grinders*". Those with a sharp edge like a chisel are the cutters ("incisors"); the flat-crowned double ones are the "grinders" ("molars"). Also let children move their jaws as in the act of eating, to show that the human teeth are moved both up and down, as in biting a bit out of a slice of bread; and to and fro in grinding or chewing it. Does a horse need any tearing teeth? (No.) Why not? (Its food needs no tearing.) Ask class for list of horse-foods. If possible, show class a horse's tooth, to indicate its size and strength. Point out that *age*, of course, largely determines the *value* of a horse, as it is used for *work*.
(*f*) *Lips.*—These are thin, delicate, and very sensitive; suitable for seizing the very smallest	(*f*) Why need the lips be sensitive? (Because the horse has to depend on them to take its food.) Tell the children to

NOTES OF LESSONS—THE HORSE—*Continued*.

Matter.	Method.
pieces of grass, thus answering the purpose of *claws* in laying hold of food.	feel the lips of a horse, when a chance arises. (Very soft.)
(*g*) *Tail*.—This is long; "docking" it is very cruel. It is made of long hairs, attached to a very short stump.	(*g*) What is the use of a horse's tail? (To brush off flies, etc., in summer.) Point out that the cow does the same.
(*h*) *Ears*.—These are pointed; they move forward, or backward; and rise or fall to express feelings. The horse pricks its ears when expecting food. A vicious horse throws them back. When frightened a horse throws the ears forward. Each ear can be moved separately.	(*h*) Draw a diagram to illustrate the shape of the horse's ears, and compare them with ours. Tell the class to notice the ears when a horse hears a noise, or even a slight sound. If a fly settle on one ear, the horse shakes it off without moving the other ear.
IV. Covering— This is made of short hair, shed in spring, when the cold weather is over. Hunters are clipped before winter. It is not so warm a covering as the sheep's wool, or cat's fur; but the horse keeps warm by swift exercise.	IV. Why is the horse not covered with fur? (Not suitable for perspiration to escape.) Why does it shed its coat in spring? (To be cool in the hotter weather.) Point out that this is like a child which, to keep cool, takes off its coat, etc., while running.
V. Method of Eating— Its food is readily digested, without interruption as in the cow. It could not walk nor run about with a mass of undigested food inside it. Its *food* consists of grass, hay, oats, beans, chaff, etc. It requires no claws on the fore-limbs to seize and clutch this.	V. What does the horse do to its food? (It lays hold of it with its lips, cuts it, and grinds it with its teeth.) Here recapitulate the part on teeth, and show how the food is broken down by these. Point out that after being chewed the food has to be *digested* in its stomach, the same as with our food.
VI. Modes of Progression— The horse has *four* paces: a *walk*, *trot*, *canter*, and *gallop*. In the *trot* the diagonal limbs move together. The *gallop* is a succession of leaps. The *canter* is nearly like a gallop, but all the feet are not off the ground together. The speed varies with the breed.	VI. Point out to the class that the *natural* mode of progression in the horse has been modified by man, to suit his fancy and taste. The horse is the most trained and domesticated animal we have, except the dog. Contrast the racer and cart-horse, in respect of speed.
VII. Uses— (1) As beasts of *burden* and of *draught*. } Alive. (2) For *pleasure*, hunting, racing, and riding. } Alive.	VII. (1) *Burden* refers to "*bearing*", or carrying on the back; *draught*, to drawing. (2) For the chase, for travelling, and for war.

NOTES OF LESSONS—THE HORSE—*Continued.*

Matter.		Method.
(3) The *hair* is used for cushions, chairs, etc. (4) The *hide* is made into leather. (5) The *tendons* and *hoofs* are used to make glue. (6) The *bones* are manufactured into knife handles etc.	Dead.	(3) *Horsehair* is long, strong, and smooth, and so fitted for weaving. (4) *Horse-leather* is the best for soles of boots. (5) The *glue* is used by carpenters, etc. (6) The *bones* are large and strong, and so make good handles, etc.

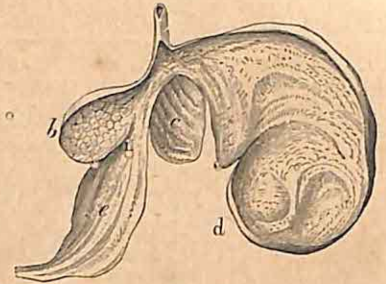
70. NOTES OF LESSONS—THE COW.

Apparatus.—Pictures of cow, horse, etc., especially of their heads; diagrams of cow's stomachs, horns, and hoof.

Matter.	Method.
I. Introduction— The cow, like the horse, is not a flesh-eater. Both *graze*, or their vegetable food is brought to them by man. Hence they are alike in many points. But, unlike the horse, the cow is not often used for hard work, not being so strongly built.	I. What kind of teeth has a cow? (Cutters and grinders.) Elicit the uses to which the ox is sometimes put. (Ploughing, drawing agricultural waggons, and in the East, threshing corn.) Show pictures of the horse and cow, and compare the different parts of them.
II. Size— The cow is not so tall as the horse; but is as long, and generally fatter (except in milch cows), and less muscular.	II. Notice that the body of the cow is larger than that of the horse, but not so strongly built for doing hard work in draught or burden.
III. Shape— Thick-set, particularly when fattened, when it is of very great weight.	III. Show, if possible, a picture of a "prize" cow, to illustrate the large bulk, and square build of the cow.
IV. Parts of the Body— (*a*) *Legs.*—To support this weight the legs are short and thick. Long and slender legs are found on animals with only slight bodies, as deer and birds. Animals with heavy bodies, as the elephant, rhinoceros, and hippopotamus, have short thick legs.	IV. (*a*) What kind of *legs* does a cow require to bear this great weight? (Strong.) Show picture of greyhound, antelope, etc., and notice that long legs are useful for *swiftness* in pursuit, or in avoiding it. Compare with the legs of a heavy and a light chair. (Dining and drawing-room chairs.)

NOTES OF LESSONS—THE COW—*Continued.*

Matter.	Method.
(*b*) *Feet.*—The cow's feet are like the horse's, hard; but different in shape; the hoof is split, or "*cloven*", with two toes; but with no separate claws. These are to be contrasted with previous animals. The feet and toes of animals are always suited to the modes of walking (*progression*), and seizing (*prehension*) of food. Contrast hoofed and clawed animals.	(*b*) Make a drawing of the "cloven" *hoof*; or show a cow's or a sheep's foot. What is the use of a hoof? (To preserve the foot against hurt, and from wearing out.) What kind of hoof has the cow? (It has a cloven hoof.) Where are cows generally found? (On grass land; the hoof opens and spreads out on the wet and spongy turf.)
(*c*) The *eyes* are situated as in the horse. The *head* and *neck* are generally short; cows have shorter legs than horses, and so shorter necks. The neck is flexible like that of other grazing animals. Compare the use of the neck with that of an elephant's trunk.	(*c*) Call attention to the beauty of the mild *eye* of the ox or cow. Why must the neck be flexible? (To reach the grass, etc., in feeding.) In a picture show that a horse has a longer neck and legs than a cow. Contrast the cow's neck with the elephant's, and the giraffe's.
(*d*) *Ears.*—These are like the dog's in position and direction, pointing outwards; while those of the horse and cat point upwards. The head differs from that of most other animals, except deer and goats, in having *horns* on each side above the ears, generally projecting outwards. Like the hoof, the horn consists of a hard case on the outside. Cattle bleed when "dishorned"; a core is then seen inside, with blood-vessels in it.	(*d*) Point out on diagram the differences in position, etc., of a cow's and horse's *ears.* What use are the horns to the *animal?* (For offence, and defence.) What use to *man* after death? (For making glue.) Why is it painful to "dishorn" the cow? (Because of injury to the nervous matter inside.) Sketch different kinds of cows' horns, such as short, long; straight, curved; recurved, etc.
V. Food— This consists of grass, green or dried; and other vegetables—swedes, mangolds, brewer's grains, etc. Hence the cow's *incisor* teeth are sharp; but there is only one row—on the bottom jaw. The upper jaw has a hard *pad*, against which the grass is held by the incisors, till wrenched off by the backward jerk of head. The "*grinders*" are very strong for crushing vegetable fibre.	V. Point out the fitness of the structure and arrangement of the teeth for their different work. Ask what different foods are given to the cow in different seasons. Show the boiled jaw of an ox, to point out the position, number, and character of the *teeth*, especially contrasting the "*incisors*" and the "*grinders*"; and show the *pad* in the upper jaw.
VI. Stomach— The stomachs of the cow and horse are very different. The cow has a stomach with *four* divisions. The grass is first	VI. Draw a diagram of a vertical section of a cow's *stomach*; and point out in it the separate parts. Compare with a man's, and contrast the different pro-



Internal Structure of Stomachs of Ruminants:—(*b*) Manyplies; (*c*) Honey-comb Bag; (*d*) Paunch; (*e*) True Stomach.

NOTES OF LESSONS—THE COW—*Continued.*

Matter.	Method.
swallowed, and then enters the large "*paunch*"; it then goes into a smaller part, provided with cells, called the "*honeycomb*". Here the food is moulded into small balls, to be passed again into the mouth, ground down, and well mixed with saliva. This is "*chewing the cud*", for which grinding teeth and a side movement of jaws are provided. It now goes into the *third* stomach. Here it is strained and passed into the *fourth*, or main stomach, where it is digested. The calf, fed on milk, does not require all these changes; the milk passes at once into the fourth stomach, and is at once digested. This stomach is then larger than the paunch, but with age the sizes are reversed.	cesses in the case of the cow with the simple one of once swallowing in our case. Why does the cow need a divided stomach? (Owing to amount of food required; and owing, in a wild state, to the necessity of retreat from level grazing grounds, the haunt of the lion, etc., to higher regions of safety among the mountains, against flesh-eaters (carnivora). What position do cows take when "chewing the cud"? (They lie down on the grass.) Point out the splendid adaptation of the calf's and cow's stomach to their different needs. Why should the calf be thus supplied with a large fourth stomach? (Because it has no strong cutting and grinding teeth yet, to cut and grind the grass, so that it is nourished on its mother's milk instead of on grass, etc.)
VII. The Cow's Covering— This consists of smooth hair. The tail has a tuft of hair longer than this, used to brush off flies. This covering differs from that of the sheep (wool) and cat (fur).	VII. What kind of *skin* has the cow? (Thick.) Why? (Lying in fields, friction would bruise the skin in time, and make a sore.) Cows are well brushed in the winter to keep them clean and healthy.
VIII. Sounds— The cow *lows*, and *moans*; the bull *bellows*.	VIII. Get these *sounds* from the children.
IX. Modes of Progression— The cow walks on the toes, *i.e.*, on the hoofs. These give a light-	IX. Point out in *Ruminants* the close connection between the *cloven-hoof* and

NOTES OF LESSONS—THE COW—*Continued.*

Matter.	Method.
ness compared with weight to be carried. It is generally seen walking; it runs when chased or excited. The bull runs furiously when in a rage.	the *ruminant stomach*: both adapted to the grazing habits of the animals. Explain to the class that a ruminant animal is one that *chews the cud.*
X. Uses— (*a*) The cow supplies us with *milk.* The best kinds of milking cows give twenty quarts a day for a time. (*b*) The cow supplies us with *butter* and *cheese*, from the milk. (*c*) The *flesh* is used for meat food, and is called beef, and veal in the case of the calf. (*d*) The *hides* are used for leather; the *horns* for knife-handles; the *tendons* and *hoofs*, for glue; the *hair* is used to mix with mortar. (*e*) The ox is largely used as a beast of burden and of draught in Eastern countries, and to a less extent for drawing waggons and ploughing on the light soils of this country. Explain that the cow is the female; and the bull the male.	X. (*a*) Milk is the only food of the young suckling animal; and the best for the young of man. (*b*) Briefly describe *butter-* and *cheese-*making. (*c*) Contrast beef with veal, mutton, and pork, in colour and tenderness. (*d*) Get from the class itself the various household articles made from these dead parts of the cow in the order set down in the "Matter" column. (*e*) Show pictures to illustrate these. Point out that all the animals yet dealt with suckle their young, and are hence called *mammals*, and so differ from *birds* and *fishes* in this respect, as well as in their *covering*, and *limbs.*

71. THE COW AND HORSE COMPARED.

A. Cow.	B. Horse.
I. Size— Height about $4\frac{3}{4}$ ft. Length about 7 ft. A fat ox may weigh above 1000 lbs.	I. Height about 5 ft. Length about 7 ft.
II. Covering— Smooth short hair, not soft like a cat's fur; nor so stiff as in most dogs. The cow has no mane, like the horse, lion, etc.	II. The horse has short hair, which is shed in spring; it has a long mane on its neck; and the hair on the tail is long and strong, and not tufted as in the cow.
III. Shape— Thick-set; neck short and thick; legs short to bear the heavy weight of the body. The breast is broad, to afford good lung space.	III. *Cart-horse.*—Thick-set, heavy *legs*, set straighter than in hunter. Broad and deep chest, with plenty of lung space. The *neck* varies in length, according to

NOTES OF LESSONS—THE COW AND HORSE COMPARED—*Continued.*

A. Cow.	B. Horse.
It is more angular and less rounded in the trunk than the horse.	breed, and length of legs: in the hunter and the racer, it is long; in the cart-horse, short.
IV. Hoofs— Hoof split (or cloven) into two; under surface flat; two rudimentary toes behind; suited for grass and soft ground. The cow chews the cud. (A ruminant.)	IV. Consolidated into one *hoof*, suited for hard ground; quickly renewed: is cut and shod for walking on hard roads. The horse is one of the solid-hoofed animals. (Solidungula.)
V. Horns— Conical, curved, with hard external hollow casing, and with internal core; they grow from the forehead. They are used for offence and defence.	V. None. Hoofs and rapid flight are its means of defence, specially the latter. Both cows and horses are "cattle", the former "*horned* cattle".
VI. Jaws— The jaws move laterally to grind food. Compare with vertical motion of dog and cat.	VI. The jaws move laterally for the molars to grind hard, dry foods, such as beans, oats, etc.
VII. Teeth— (*a*) *Incisors*: none in upper jaw; a hard pad instead. Those in lower jaw hold the food against the upper pad. (*b*) *Molars* are used for grinding in ruminating; but the food of the cow is not so hard as that of the horse, so its teeth are different.	VII. (*a*) Six *incisors* in front in each jaw; then a small space, then four *canines*, one on each side of (*a*). (*b*) Six *molars* on each side of each jaw. The age is told by the teeth.
VIII. Nose— Nostrils prominent, large, and always kept moist. This part of the cow is not so moveable as in the horse, but drawn tighter over the bones.	VIII. Fleshy; the nostrils are open, and can be widened in rapid breathing in violent exercise. It can draw hay out a hay rack by its lips. The sense of smell is acute in the horse.
IX. Eyes— These are large and mild, so that we get the term of "ox-eyed". Note the position and compare with horse's. In a wild state (buffalo), the horns close to the eyes impede the sight in several positions.	IX. Large; situated so as to give great range of sight. Over the centre is a green pigment for the horse to see well in a faint twilight. The sight is directed in front by use of blinkers.
X. Ears— These project sideways under the horns: compare the project-	X. These are short, pointed, erect, and moveable separately. They can be pricked

NOTES OF LESSONS—THE COW AND HORSE COMPARED—*Continued.*

A. Cow.	B. Horse.
ing, and erect ears of cat, dog, and horse. Hearing is not needed to be so acute in the cow as in the horse, as she has horns for defence.	when the horse is expecting food; they are thrown back if vicious; and thrown forward in a fright. The hearing is acute in the horse.
XI. Tail— This is long, ending in a tuft of hair; it is used to brush away flies.	XI. Long, coarse hair on short stump; used to brush off flies, so should not be cut.
XII. Sound— The cow *lows*; the bull *bellows*.	XII. The horse *neighs*, or *whinnies* to call its fellows.
XIII. Locomotion— The cow walks on cloven hoofs, which give lightness as they spread out somewhat under pressure of the weight of body when on spongy, boggy grass. The cow is not so swift as the horse; and is less suited to hard roads.	XIII. The horse has four paces—(1) *walk*, (2) *trot*, (3) *canter*, (4) *gallop*. In (2) the diagonal limbs move together; No. (4) is a succession of leaps; No. (3) is nearly like (4), but all the feet are not off the ground together. The speed varies with breed.
XIV. Feeding— The food entirely vegetable, and is *cropped* off by incisors and pad; and roughly *bruised* by molars. It is swallowed, but not at once digested. It first goes through the paunch to the second stomach; and is made into pellets, "quids" or "cuds". Afterwards these are thrown up again and chewed; and then sent to the third and fourth stomachs, and digested. The calf lives on milk; so uses only the last stomach.	XIV. The food is entirely vegetable; the lips are delicate organs of feeling, to crop the short grass; the upper lip prehensile. The *incisors* cut off herbage close; the *molars* grind it. Digestion is continuous, not as in cow; so the horse can work continuously, not having a mass of undigested food inside. The amount of water taken varies with the work done. It should not drink when heated, nor when doing hard or quick work.
XV. Uses— The cow supplies *milk*, *butter*, and *cheese*; the best kinds give 20 quarts of milk a day. It also supplies *flesh* (beef); and is used for threshing, ploughing, and draught (agriculture) in the East; and in England on light soils. The *skin* makes leather, the *bones* knife-handles, and the *horns* glue.	XV. The *flesh* of the horse is not eaten, nor its *milk* used by us; the *hair* is used for coverings of cushions, sofas, chairs, etc.; the *hides*, for leather, belts, straps, laces, etc.; the *tendons* and *hoofs* make glue; the *bones*, knife-handles. It is employed as a beast of burden and of draught; for hunting, racing, driving, riding, etc.

72. THE WHALE.

INTRODUCTORY SPECIMEN LESSON.

I. Fishes.—I dare say most of you think that all animals that live in the sea are **fishes**. But a fish breathes by means of **gills**, which are those red fringes which you see on the sides of the head of the cod, mackerel, etc. Fishes also have **cold blood**, or blood of the same heat as the water in which they live.

II. Mammals.—But there is another Class of animals called **Mammals**. These :—

(*a*) Breathe by means of **lungs**.

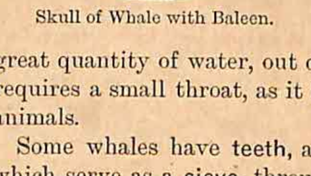
(*b*) Have **warm blood**, and

(*c*) **Suckle** their young with milk.

(*d*) Most mammals, again, have **hair** as a covering for the body ; but the full-grown whale, which is one of these mammals, has none.

These warm-blooded animals mostly live on the **land** ; but some few live in the **sea**. The **whale** is one of these latter ; so, though the whale lives in the sea, it is not a fish, but a mammal, with lungs, warm blood, suckling her young, and having hair at one time of its life.

III. Description.—The whale is very **large**, sometimes eighty feet long, and weighs a very great deal. The **head** is also very large, sometimes nearly half as long as the rest of the body ; whales also have very large **mouths**, some large enough for twelve men to sit down to dinner in this odd dining-room.



Skull of Whale with Baleen.

But though the mouth is so large, the **throat** is very small. The whale requires a large mouth to take in a great quantity of water, out of which it gets its food. But it only requires a small throat, as it lives on and swallows only very small animals.

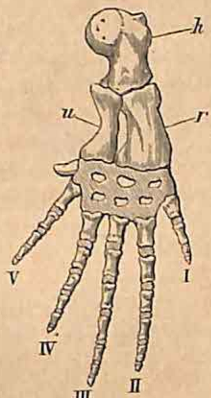
Some whales have **teeth**, and others have plates of **whalebone** which serve as a **sieve**, through which to sift the water they take into their mouths, and to strain out from the water the animals in it which form their food. This **whalebone** hangs down from the roof of the mouth. It is used for women's stays, and for umbrellas, and other purposes where lightness and strength are required.

IV. Habits.—The whale lives in very cold seas. To keep it warm, it has a thick covering of **blubber**, or fat, all over its body.

It is for this that it is killed by the whalers; who melt the blubber down into train oil. A single whale sometimes gives above 3,000 barrels of oil. The blubber also makes the animal light, so that it can rise to the surface. This it is obliged to do every now and then to get air, as it breathes by lungs, as all mammals, including human beings, do.

The whale has two fins (flippers) and a powerful tail, by means of which it swims with great rapidity.

When the whale is struck with the harpoon,—which is a kind of spear with a long rope tied to it,—it sinks to great depths, and sometimes turns over and over, so as to coil the rope round itself. But it is at last obliged to come again to the surface to breathe. Then the whalers row towards it, and if they reach it, strike the animal again and again with their harpoons till from loss of blood it becomes feeble, and at last dies. Sometimes the whale drags the boat a long distance after it before it is killed.



Skeleton of the Fore limb or Flipper of the Whalebone Whale.

The whale is very fond of its young. When whalers come into a "school" of whales, or a great number of them; or when a whale and its young are left in shallow water by the tide running out, the mothers place themselves before their young, to save them from the harpoons of the whalers.

When the whale rises to the surface to breathe, the hot air expelled from the lungs, coming in contact with the cold air above, produces condensation of the moisture in the expired breath and the appearance as of columns of water being spouted up. This appearance has led to the erroneous belief that the whale took in water by the mouth and spouted it out through two holes in the top of the head called "blow-holes". From these the water rises like a small fountain.

V. A Whale Hunt.—Every whaling ship has a kind of box fitted up at the top of the mast called the "crow's-nest". Here a man is kept on the watch, to see if there are any whales spouting about the ship. When he sees any, he shouts out, "Whale, ho!" Then those below shout out, "Where away?" The man tells them in what direction, and how far off the whale is.

Boats are then let down from the ship by night or by day, with men and harpoons in them. To each harpoon nearly a mile of rope

is attached. The men row up to the whale; and strike it with the harpoon.

After being struck, the whale dives down, or swims rapidly away, carrying the harpoon with it. The boat follows in the track, having the rope tied to the harpoon. This rope runs out so quickly over the boat's side, that the men are obliged to keep throwing water on it, or it would burst into flames with the rubbing. A man also stands ready with a chopper, or hatchet, to cut it if the whale attempts to drag them beneath an ice-floe. For the whale sometimes makes for a field of ice; and then, if the rope were not cut, it would drag the boat and men under the ice.

Sometimes, too, the whale strikes out with its powerful tail, and smashes the pursuing boat.

VI. Uses.—The people of cold countries when pressed with hunger eat the **flesh** of the whale; but it is rather tough. They also use the **bones** as props to buildings; and now and then we see these bones in England used for posts for field-gates.

The **sinews** are employed by the natives for bowstrings. The **whalebone** of the mouth is used by the English for stays and umbrellas. The **fat** is melted down to make train-oil.

73. BIRDS.

INTRODUCTORY SPECIMEN LESSON.

I. Why interesting.—(*a*) **Birds** please us with their graceful **motions**, either in flight through the air, or hopping and flitting about from bough to bough in search of food for themselves or for their young.

(*b*) They also please the **ear**, and the **eye**, by their **song** and **bright colours**; but those birds that are beautiful in their feathers, or in plumage, mostly are wanting in song.

II. What Birds are.—If I ask you children whether you know what a bird is, you will say "Yes!" at once: let us see what it is that enables you to answer so readily.

(*a*) The first thing that strikes us in a bird is its **clothing**, or its **feathers**. No animals have feathers except birds; and nearly all birds have feathers.

Mammals, or animals that suckle their young, or feed them on milk, have **hair**, **wool**, or **fur**, instead of feathers. **Reptiles** have **bony plates**; and **Fishes** mostly **scales**, instead of feathers.

This outside difference is very great, therefore, between birds and other large animals.

(*b*) But besides this outside difference, there are some differences which are not so easy to find out. Birds have **warm blood**; and reptiles and fishes have not. The higher animals that suckle their young, or the mammals, also have warm blood; but their blood is not so warm as in birds. Birds are very **active**; and move about very rapidly. You know when you move about very quickly, you get warm; and you become hotter at these times than when you are still. That is one reason why birds are warmer than any other animals.

III. Kinds of Birds.—There are many **kinds of birds**:

(*a*) Some of these live on **land**:

(*b*) And others on **water**:

(*c*) And some partly on land, and partly on water.

(*d*) Some again **perch** on trees, as pigeons and doves.

(*e*) Others feed upon **animals**, and are **birds-of-prey**, such as eagles, which feed on **living** animals, as the lamb, hare, and rabbit; and vultures, that feed on **dead** flesh.

(*f*) We have also birds which are **swimmers** with **webbed feet** to move through the water, as ducks, geese, and swans.

(*g*) Then there are **waders**, that live in or near pools, and shallow sheets of water. These do not have webbed feet, but their legs are **long**, to enable them to walk about in the shallow pools. Or, they have **long toes** to help them walk upon the floating leaves of water-plants.

Scratching Birds:—(1) Head and Foot of Jungle-Fowl; (2) Do. of Common Pheasant; (3) Do. of Wild Turkey; (4) Do. of Common Grouse.

(*h*) Some, again, are called **climbers**, like the parrot, which climbs up trees in its **wild** state, and the bars of its cage when **tamed**, by means of its toes and beak. The parrot uses its beak like a hand, as you see when it climbs about the cage, up and down, and across the wires.

(*i*) Others are **runners**, like the ostrich, and travel rapidly over the ground; and have strong legs, but weak wings. Ostriches can thus run with the wind as swiftly as a horse can gallop; and so,

when they are hunted, the huntsmen are forced to run them against the wind.

(*j*) Then there are birds called **scratchers**, such as fowls or poultry, which have had their name given to them because they scratch up their food with their short, strong talons or claws. And this is a good name, as you know, if you have kept a garden into which cocks, hens, and chickens could come. You soon knew then that they could scratch up the soil to get at seeds, worms, and insects in it.

IV. Birds are Light.—As birds fly in the air, they require very **light bodies**, and so their **bones** are **hollow**. They have lungs filled with air such as we have, but they have also **air-cells** in other parts of their bodies which help to keep them light and which give them air to aerate the blood when they could not breathe it in their rapid flight.

V. Some English Birds.—Among the birds which we find in England are the wild **duck** and the wild **goose**; and more common than these, the **sparrow**; the **hawk**, which feeds on other birds; and the **owl**, which flies by night. There are also the **lark**, which builds its nest on the ground, and flies very high; the **tomtit**, which builds in holes in trees; the **wren**, which builds its nest in banks of ditches, and is very small; and the **thrush** and **blackbird**, which build their nests in furze and other low bushes.

The **robin**, or redbreast, makes friends with us in the winter, when food is scarce, but, like a false friend, leaves us in summer. The **goldfinch** has bright plumage on the head, breast, and wings. There are, besides, many other birds that every boy and girl can name, such as the **crow**, and **rook**; the **jackdaw, magpie, wild grouse, common pheasant**, etc.

VI. Foreign Visitors.—There are also birds that live in **other** countries, such as **parrots, jungle-fowl, wild turkey**. Some, like the **swallow**, and the **cuckoo**, visit us only in the summer time; others only in the winter, as **wild swans**. There are also some that fly about over the **sea**, as the **curlew** and stormy **petrel**; and the **stork**, which lives in chimneys in other countries.

74. THE SPARROW.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Kinds.**—This is the most common of all European birds. The chief **kinds** of sparrows are the field, song, tree, chirping, and snow sparrows. Prior to 1860 there were no sparrows in Australia; they were then introduced to destroy the insects which injured the produce of the gardens and orchards there. These birds have also only been comparatively recently introduced into America, where they have spread rapidly.

II. **The Common Sparrow.**—We call one kind the **Common** Sparrow, because it is met with everywhere. These birds belong to the same family as the goldfinch, weaver-bird, and canary.

The **bill** is sharp, that of the male being lead-coloured, and the female's brown.

The common **colour** of the females is brown: the male's body is varied in colour.

They **feed** chiefly upon fruits and grain. Their appetite is very voracious: a pair of sparrows kill on an average every week in summer between 3,000 and 4,000 caterpillars. They also plunder the grain-fields to a great extent, and the corn harvest often suffers from them. But they have also their **uses**; as they destroy insects, and scatter seeds which drop from their mouths.

The **note** of this bird is not pleasing. The male announces his approach with a chirp.

It **builds** beneath eaves, and in any cavities, laying two or three sets of eggs in a season. Its nest is better built than those of the larger birds, as it requires much warmth: hence we find the greater part of it is composed of hay, wool, etc.

If attacked, it will **combat** birds ten times as big as itself; and is too crafty to be easily ensnared. If we watch some neighbouring tree where there is a chirping sparrow, we hear it cheer his mate with his notes, to assure her that no danger molests her. At a sign of immediate danger, the male ceases singing; and both take to flight.

In the autumn large numbers of sparrows are caught in nets for the London markets. Great skill is required to catch them, as their hearing is very acute.

The young ones are taught to fly by the parent-bird. When fully fledged, they are taken a few yards from the nest, and left to

return. If successful, this distance is increased until they can shift for themselves.

III. The Sparrow-Hawk.—The Sparrow-hawk is nine inches long. Its beak is **hooked**, like the parrot's. In its wild state, it commits great havoc among the smaller birds. Falconry was carried on in the middle ages amongst the nobility by means of this bird. In the reign of Edward III. it was made felony to steal one of them.

75. THE CUCKOO.

INTRODUCTORY SPECIMEN LESSON.

I. What the Cuckoo is.—If you have not **seen** a **cuckoo**, you must have **heard** one if you live in the country.

This bird obtains its name in this and other countries from the cry it utters, which is a sound like its own name.

II. A Climber.—The cuckoo belongs to the **climbers**; but it is not so easy to put this bird in its place among them, as is mostly the case, since it is different from most climbing birds. Cuckoos do not, for instance, use their **bills** in climbing, as **parrots** do; nor do they make **holes** in trees, like the **woodpeckers**.

III. A Visitor.—Cuckoos in this country **leave us** before the **winter**, or, like the swallows, they only visit us in the summer time. Before winter they fly away to spend their time in hotter countries. Perhaps the reason they do so is because they have such thin and tender skins that they cannot stand the cold here, though protected by feathers.

The cuckoo comes to us about the first week in April; and leaves us in the last week of June; only staying here, therefore, about three months at the very most.

IV. Description.—The cuckoo has long **wings**, and these are rather pointed. Of the two classes of wings, **pointed** and **round**, those of the cuckoo may be said to belong to the former division. The birds which have pointed wings are always the best **flyers**. As the cuckoo has to take such long flights when it leaves us to visit warmer countries, we see why it has pointed wings.

The **feet** are short, and the **legs** covered with feathers. The cuckoo has a bad name, because it does not build a nest of its own; but coming to us late in the spring, lays its eggs in the nest of some **other** bird. It mostly chooses one that is well hid in thick bushes; and is often the uninvited guest of the **hedge-sparrow**.

In size, the cuckoo is about fourteen inches long, from the beak to the end of the tail; and weighs a little more than a quarter of a pound.

It has a black bill, or beak, which is, however, of a yellow colour at the base; and the inside of the mouth is red.

The cuckoo feeds largely on grubs; and is fond of those that are hairy. It will also eat dragon-flies, some of which it catches as they settle in woods; and others as they are on the wing, or in flight.

76. MANUFACTURES: PAPER.

INTRODUCTORY SPECIMEN LESSON.

I. Old Rags.—How carefully you fold me up, and put your name on my back, when I turn up in the shape of a bank-note! And yet I dropped from the back of a beggar!

I can well remember the time when I was an old rag, not very clean, and with all the colour washed out of my cheeks by the rains of winter; or stained by the dirt of the gutters. You would then have turned up your nose at me; and not stooped to pick me up, for fear of soiling your dainty fingers.

II. Gathering and Sorting.—But what a struggle I have gone through to become what I am now.

First, I was picked out by a man, who took me out of the old bag behind his back in which he had at first placed me, and sorted me out with others into a heap by ourselves. What strange company I found myself with in that old bag! A bit of a red coat that had been in the wars, and was riddled by bullets; the torn fingers of a silk glove, that had been on the hand of a dainty dame; a shred of canvas that had been in almost every part of the world; a tatter of a shawl; the fringe of a baby's cloak; the tassel of a smoking-cap; and many, many other odds and ends from better days.

III. Washing.—First, I was well washed; and after this I felt quite proud of myself! My skin had been white in my younger days; and now I became white once more.

IV. Made into Pulp.—But my next change was a cruel one: I was put into a rolling tub filled with iron spikes, and torn to pieces without mercy, till I lay a helpless pulp at the bottom of the tub. Soaked through and wretched, I was next fished out, and laid on a fine wire sieve; through which the water drained,

leaving me as thin and flat as could be. I was next with others spread out on a line to dry.

V. Rolled and Pressed.—I was then pressed between heavy rollers; but I was already so thin and smooth that this did not hurt me much. When I came out of this trial, I found that I was stamped and numbered. From this time people took almost as much care of me as of a bank note.

VI. Printing.—I was next dipped in size, to stop the ink running in me, as I was then like blotting-paper.

VII. Materials.—Many other things have been used to make me besides old rags; such as certain kinds of grass, etc.; but paper made from the latter material is brittle and apt to break.

VIII. Books.—For a long time books were printed by hand. But after some thought, a machine was made to do the printing part of the work. Now boys merely have to put us into one end of the printing machine, and we come out at the other end, printed on both sides at once. In some printing-works you will even see machines which pick us up in sheets after we have been printed, and place us in order on the top of each other.

77. NOTES OF LESSONS—PAPER.

Apparatus.—Note, and blotting-paper: linen rag, strip of parchment, brown paper, and pith of rush.

Matter.	Method.
I. Writing Materials—	
(*a*) Before paper was invented, *skins of animals* were used for writing on. These would *last a long time*, and so be well preserved. Goat-skins were first used, and we call these and sheep-skins used for the same purpose, *Parchment.*—This word takes its name from the place where it was first used in making a famous old library.	I. (*a*) Ask children what men would want to write at all for. To sign agreements after war (*Treaties*), to record *sales* of lands, goods, etc., and to hand down *history* of events, etc. Point out that the first thing to regard in choosing writing materials would be something that would *last well*, *not* easily *tear*, nor spoil with wet.
(*b*) Before this thin strips from a reed were used. This reed was called the *papyrus*, which thus gave the name to our word *paper*. This was done in Egypt, where the children of Israel were kept in bondage. Many of these old writings have been kept till now, for more than two thousand years.	(*b*) *Ink* would not be first used. Point out that a child writes on the *sea-sand* with a stick; or in the *dust* of the road. So *wax* spread over smooth tablets, and scratched with an iron pen, would leave marks, as one of the earliest forms of *writing*.

NOTES OF LESSONS—PAPER—*Continued.*

Matter.	Method.
(*c*) *Paper*, as we now understand it, was first made by the clever *Chinese*, nearly two thousand years ago. It was not made in *Europe*, the continent where we live, for 1200 years after this; and not in *England* till 1600 years after. It was first made here at Dartford in Kent; and there are still paper-mills there now.	(*c*) Remind the class that the *Chinese* are most famous for having *invented* things when we were yet quite savages, or Ancient Britons: they thus invented *gunpowder* and *printing*, kept *silk-worms*, etc. Travellers going there brought back to us some of these clever inventions. Point out Dartford on a map of England, and explain that it is near London, where much paper is used.
II. What made of— (*a*) At first paper was made of *linen*; and white *linen rags* make the best, the finest, and toughest, papers now. (*b*) Afterwards *cotton rags* were used, as cotton is so much cheaper than linen. (*c*) Then as so much more was wanted for books and newspapers, a certain kind of *grass* grown abroad was used. ("Esparto", or "Spanish grass".) *Brown paper* is made out of *hemp*, old *rope* and *canvas*. (*d*) After that *wood* was called in to help. This is very hard and tough, but it consists of the same vegetable matter as flax, hemp, and Spanish grass.	II. (*a*) Show the class a linen rag, and a cotton one; and contrast the two in resisting *tearing*, to show their difference of strength. (*b*) Show that cotton rags are also *white*, like linen ones. (*c*) Show some Esparto grass; or a cheap *newspaper* made of it; and point out that it "crackles", and is not so good as paper made from other materials. Show some *brown* paper, some *hemp*, *rope* and *canvas*. (*d*) Explain how wood, and sawdust from it, could be *mashed* into a *pulp*, and made soft and white by proper treatment.
III. Properties— In all these cases, the materials are beaten into a fine *pulp*. This when dried in *thin sheets*, gives us what we want: something that is *white*, and which will *bend*, *take ink*, and be *tough*.	III. Illustrate all these properties by reference to a sheet of *note paper*. Get from the children how the absence of each would impair its value for writing or printing on, for wrapping purposes, etc.

78. NOTES OF LESSONS—CORK.

Apparatus.—A bottle cork, a bung, a piece of virgin cork, bark of oak, elm, and birch; a piece of linoleum, a fishing-net "float".

Matter.	Method.
I. What Cork is— The *outer bark* of a tree like our *evergreen oak*, growing in a country	I. Show the class the *barks* mentioned in "Apparatus". Call attention to their

NOTES OF LESSONS—CORK—*Continued.*

Matter.	Method.
which is warmer than ours, called Spain. This tree grows to forty feet in *height*, and is from two to three feet through in *thickness* at the bottom. It lives to a *hundred and fifty* years, the bark beginning to thicken into cork when it is *five* years old.	*varying thickness* from elm or oak, to birch. Remind the class of their previous lesson on "*bark*", and the use of this to the tree or plant. Now place a strip of *virgin cork* side by side with oak or elm bark, to show their likenesses and differences.
II. How Obtained— When the tree is *thirty* years old, the bark is removed; and this is done again and again about every seven or eight years. When the tree is *forty* years old, the bark is fine and close enough to make corks for *bottles*. The bark is cut across in rings round the tree (*transversely*): then up and down (*vertically*). It then comes off in *strips*, which can be flattened out by great weights when laid on the ground.	II. Remind the class that if the inner as well as the outer bark of trees were removed they *would die*; and that we, therefore, protect our young growing trees by strips of wood or fencing. In the case of the cork tree the outer bark only is removed, and the tree grows *better* after the removal. Show how the cork is *cut away* from the tree, by making similar incisions in a growing *willow* sapling, and stripping the bark off it, and flattening it out on a table or desk.
III. Qualities and Uses— (*a*) *Light*: and therefore used for "*floats*" to nets. It is light because it contains spaces filled with air. It is used for buoys and life-preserving jackets, and floats and in life-boats.	III. (*a*) Get this property from the children, and illustrate it by a coin and a cork placed in a saucer or basin of water: the one "*swims*", the other "*sinks*"—and ask the reason why. (One, the coin, is heavier; the other, cork, is lighter than the water.)
(*b*) It can be *squeezed*, and then comes back to its old shape. This is partly what makes it fit for corks for *bottles*, as these can be squeezed to fit tight into the narrow necks. This quality of its coming back to the old shape, is what we mean by calling cork *elastic*. In this respect it is like india-rubber.	(*b*) Show the smaller and the thicker end of a cork that has been used. *Draw* one with a corkscrew out of a bottle of ginger-beer, etc. Compare this *elastic* quality with that of *india-rubber*: and show class that wood could not be used for bottles, because of the want of this property.
(*c*) It can be *cut* like wood, so that it can be shaped into corks for bottles, etc.	(*c*) *Cut* a piece of cork before the class with a very sharp knife.
(*d*) It stops *liquids* passing through it, so is useful for bottles, and linings to shoes to keep out the damp ("cork-soles").	(*d*) Hold a bottle of some *liquid* (ginger-beer, etc.) upside down: cut the cork in it to show it is not wet *inside*.

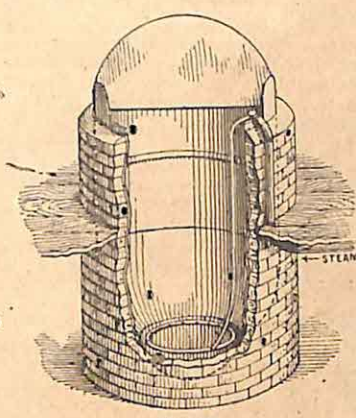
79. NOTES OF LESSONS—CANDLES.

Apparatus.—A wax, a paraffin, and a tallow candle: some palm oil, and paraffin in different stages of manufacture. These will be supplied to schools from Messrs. Price, Belmont Works, Battersea, London, S.W.

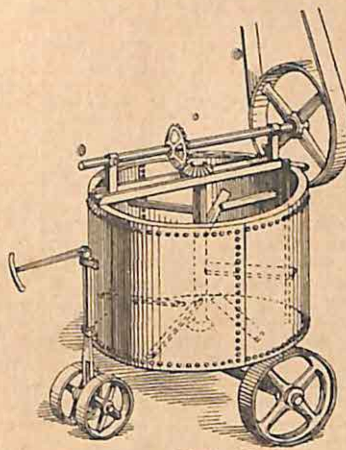
Matter.	Method.
I. Tallow Candles— These are made of the "*rendered*" fat of the ox and sheep. The *rendering* consists in boiling the fat with water, and removing all the stringy and other parts that are not pure fat. The *wicks* consist of loosely woven, or twisted, cotton threads. These are hung on a *frame*, a hundred at a time, and dipped into the "*Dipping Trough*" of melted fat, which then soaks into the wicks. When the first *layer* of fat on the wicks has cooled, they are dipped again to receive another *coating*, and so on, until the candles are of the proper size and weight, say twelve to the lb. The *braided* wick consumes at the top, outside of the flame; and so requires no *snuffing*. Something is used to make the braided wick burn to ashes at the top.	I. Ask the children what mother does at home with *fat* not wanted to eat. (She "*renders*" it down, by *melting* and passing it through a strainer, pouring it also into cold *water* to set. The fat swims at the top, the impurities mostly fall to the bottom.)  Show a candle wick, and *untwist* it, and undo it if *braided*. Illustrate the *rapid cooling* of fat by pouring some melted fat from a spoon on a cold slate, and into water. Refer to the *number* that is generally given in buying candles, as 6, 8, 12, etc., to the lb. Explain that candles are thus sold according to *weight*. Show by burning a *twisted* and a *braided* wick, that the former does not wholly consume; and that the latter does so to a fine ash. Get from the children the inconvenience of using *snuffers*.
II. Other Candles— Better candles are made out of *dearer* materials, such as solid paraffin, and bees-wax: the oil of the sperm-whale, palm-oil, etc. These materials are *clarified*, or purified after melting, and the solid fat separated out. The *paraffin* is made out of coal and petroleum, or mineral oil. It can be bought in a whole solid form, or as a liquid in the oil used to feed lamps. The *bees-wax* is made by bees from flowers. *Palm-oil* comes from the palm-oil tree. *Wax* candles are not *moulded*, nor *dipped*; but the melted wax is poured over the wicks.	II. Show different candles from the specimens procured: give the *names* and *sources* of each: but point out that fat, oil, wax, or grease, is common to them all. Show *liquid* and *solid* paraffin: and some *petroleum*. Show a piece of bees-wax, and throw a portion into a fire to show that it will burn (combustible). Show class a bottle of *crude* and *refined* palm-oil. Refer to similarity of the process to that of dipping tallow candles in the dipping-trough of melted fat.

NOTES OF LESSONS—CANDLES—*Continued.*

Matter.	Method.
The candles are then laid on a slab of marble, and rolled under a board, like butter when made into rolls.	Explain that the *marble* is hard and will not give way: the wax is soft until quite cold, and yields to pressure, and so takes the shape required.
III. Moulding Candles— This is the commonest way of making candles. The *mould* is the framework into which the melted material is *cast*. It is made of pewter, and the wick runs through it. The material is cooled by *cold water*.	III. Explain the principle of *casting* or *moulding*, by the way in which clay is thrown into a brick-mould in a brick-field. Further illustrate by casting in the making of cast-iron articles, and the setting of melted iron in "*pigs*" and "*sows*" (*Vide supra*, Standard I. Iron).
As many as 2000 different kinds of candles are made, according to *size*, *quality*, etc. The dearest are made of bees-wax, and are sometimes ornamented in colours on the outside.	Get from the class that some candles are *cheap*, others *dear*: some *large*, others *small*: and that they are made of many different *materials*.
IV. A Burning Candle— The candle is lighted by applying a *flame* to it, as great *heat* is required for this. This heat, and that of the burning wick, *melt* the wax, etc., at the top. The melted wax, etc., *rises* up in the wick, as water does in a towel left hanging in water. The melted tallow, wax, paraffin, etc., may be seen thus rising up between the threads of the wick if carefully watched.	IV. Refer to the different ways of lighting a candle, by a lighted *match*, *spill*, or piece of *paper*. If the wick were not full of oil it would *char*. Show that it does so at first at the top: and that it will do so throughout, by burning a piece of wick without any fat, etc., on it. Hang a pocket *handkerchief*, a piece of *blotting paper*, or a strand of *cotton*, over a tumbler with the edge in the water.
As the candle burns it turns into *bad air*, *smoke*, *flame*, and gives out *heat*. It also, with air, makes *water*.	Show this by inverting a cold clean tumbler over a lighted candle and on a slate. The inside is soon covered with a mist.
The candle will not keep on burning without a fresh supply of pure air.	Show this by letting the candle-end under the tumbler go out. On the point of doing so revive it, by tilting up the edge of the tumbler.
The flame is *pointed*, tapering *upwards*; the air coming in from all round makes it take this shape, as the hot air rises. It *flickers*, if draughts blow in on it.	Illustrate by the *shapes* and *motions* of flame in a fire-grate: and by letting the wind through the *key-hole* blow aside a lighted candle. Make the candle flicker by *blowing* on it.
It is of a *reddish-white* colour. In the middle is a dark part where the air cannot get to turn it into flame.	Refer to white and pale red as the *general* colour of flame in all candles, in gas, and over the fire in the grate.



Boiler.



Scratching or Mixing Machine.

80. NOTES OF LESSONS—SOAP.

Apparatus.—All the various soaps, and other materials, mentioned in the lesson below.

Matter.	Method.
I. Manufacture— Ordinary soap is manufactured in the following manner:—Fat, animal, vegetable, or mineral, but chiefly that of animal origin, is placed in a copper or boiler. Either of the *alkalies*, "soda or potash", is added by degrees; also a small quantity of another alkali, common salt. This mixture is *boiled* three or four times; the liquor is then removed and allowed to *cool*. The resulting product is cut into *tablets* for use.[1]	I. Shake up together in a bottle *oil* and a strong *solution of soda*. Pour the mixture into a basin, and let a boy rub his hands in it, to test the soapy feeling (alkaline) it has. Boil half a *tallow candle* with some soda; and add a little salt. Allow the mixture to cool. Remove the cake of soap formed, and pass it round the class for examination by the children. They will recognise that this is a kind of home-made soap.
II. Kinds— There are many different kinds of soaps; all, however, made in a similar manner. (*a*) *Yellow soap* has *resin* added to the other ingredients. The	II. (*a*) Show class a lump of resin, and tell children that it is obtained from the

[1] This simple description gives the *materials* used, and the *processes* employed: but the subject is treated in detail in Hassell's "Common Things".

NOTES OF LESSONS—SOAP—*Continued.*

Matter.	Method.
soap made is of the same colour as the resin used.	fir tree. Make soap as in the second experiment above, add *resin*, and allow all to cool.
(*b*) *Soft soap.*—This is made in the same way as ordinary soap, using, however, *potash* in place of soda, and a mixture of whale, seal, olive, and linseed oils. Ordinary fats may be and often are, used alone. The speckled appearance of this soft soap is due to the mode of preparation it undergoes.	(*b*) Explain that *soft soap* is a useful soap for scouring, being of a *stronger* nature than ordinary soap. For this reason it is not fit for the skin. Show specimens of soft soap, and make a lather with it. Soft soap lathers more quickly than hard ones; but sooner wastes away.
(*c*) *Mottled soap.*—This consists of fat, soda, salt, and sulphate of iron. The latter is one of the iron-ores, and has sulphur in it.	(*c*) Prepare in the same way as in second experiment, putting in a small quantity of *sulphate of iron.* If not practicable to make, show specimen.
(*d*) *Marine soap,* consists of cocoa-nut oil, soda, and salt. Here we have an alkali and a fat as before, but the fat is not the same as those used previously. Aboard ship clothes have to be washed by the passengers themselves, if poor; or by the sailors. Some special soap is therefore necessary that will give a lather in sea-water, as it is the lather that mixes with the dirt.	(*d*) Try to make a lather with *ordinary* soap in *salt water.* Procure a tablet of *marine soap*, and make a lather with it in salt water, to show the difference in the action of the two kinds. In the latter, *cocoa-nut oil* is used, instead of ordinary fat; this counteracts the salt, and renders the soap useful at sea where salt water alone can be obtained for washing purposes.
(*e*) *Coloured and scented soaps.*—These are made in the same way as ordinary soap, with the addition of *colouring* matters and *scents.* *Highly* scented and coloured soaps should be regarded with suspicion, as they are frequently made out of very impure fatty materials. The colour and scent hide the disagreeable smell of these common materials.	(*e*) Show *coloured* soaps, and explain that these are made in the same way as in the second experiment, the *colouring* matter being added. *Scented* soaps are made in the same way, with *scent* added. Tell the children that dishonest soap-makers often buy bad fat, for *cheapness*; and make it up into soap, hiding the smell and colour by scent and colouring matter.
III. Uses— (*a*) To dissolve, and loosen, dirt and grease from *clothes.* We buy soap a week or more before using, and always use soft water for cleaning and washing. The soap unites with the grease and dirt of the *clothes*, or *person*, and floats with it to the top as *scum.* This scum is got rid of with the water used in washing. But with *hard* water the soap	III. (*a*) Draw from the class some of the *uses* of soap, viz., to remove *grease*, and *dirt.* Let the children wash their *hands*, one with the other, without soap. *Articles* washed in soapy water, become clean sooner than without it. Show soap which has been dried; scrape it, also a piece not dry. One scrapes finer than the other. Make a lather with each, and show the economy of using dried

NOTES OF LESSONS—SOAP—*Continued.*

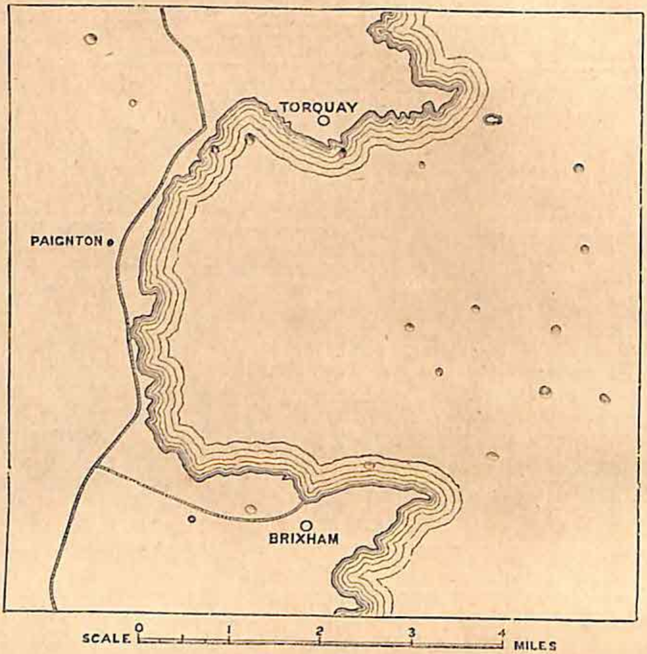
Matter.	Method.
unites with something that makes the water hard, instead of with the dirt.	soap. Dry soap lasts longer, and goes further, than freshly made soap. Make a lather in hard water, and in soft; the hard water takes more soap than the soft.
(*b*) To do the same for *furniture* (floors, tables, pots and pans, etc.).	(*b*) Tell class that some soaps are specially made for this purpose, as Brooke's Soap.

NATURAL PHENOMENA.

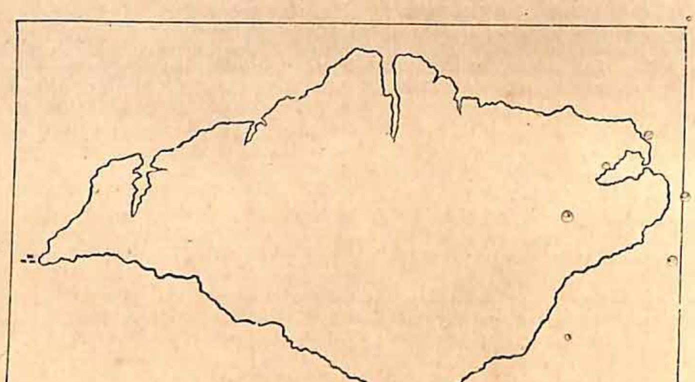
81. NOTES OF LESSONS—THE SEA AND ITS SHORES.

Apparatus.—A map of England, modelling clay, pictures of the items mentioned.

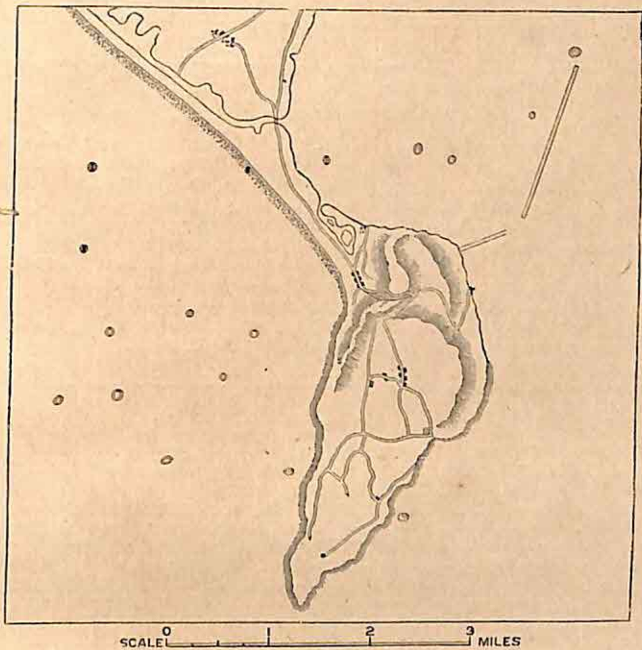
Matter.	Method.
I. Bay, Gulf, and Estuary— All these are forms of inlets breaking the evenness of the coast line. (*a*) *A bay* is a *broad* opening (somewhat like a "bite" out of a slice of bread).	I. *Form* clay models of these three openings in the land. Point out illustrations of them on a map of England, viz.:— (*a*) *Bay.*—As an instance point out Torbay on a map of England.
(*b*) *A gulf* runs further up into the land, *narrowing* towards the end. The mouth of the one (bay) is a wide opening, that of the other (gulf), one which is almost shut.	(*b*) *Gulf.*—As an illustration show on the map the Bristol Channel, but without giving the name of this, as the term "channel" might lead to subsequent confusion.
(*c*) *An estuary* is the widened mouth of a river up which the *tide* runs, carrying in salt water for some distance inland; and carrying out to sea the mud brought down by the river. Twice a day (twenty-four hours) the tide *flows* up and *ebbs* down the estuary. As it does so it laps against the banks of the river, and washes them away, and so with time makes the estuary wider and wider. Thus at the last the estuary may become a *gulf*.	(*c*) *Estuary.*—Illustrate by the Nore, or mouth of the Thames, and ask the children for others, *e.g.*:— (1) The Bristol Avon. (2) The Humber, or Mersey. (3) Mouth of the River Severn. A gulf and bay can be illustrated by the opening between the body and the arm raised from the side, widely (for bay), and only a little (for gulf). Show a picture of an *estuary* with ships taking in, and bringing out goods: and explain the use of the tide to assist in the ebb and flow.



Map of Torbay.



Coast-line Map of the Isle of Wight.



Map of Chesil Beach and Portland Bill.

NOTES OF LESSONS—THE SEA AND ITS SHORES—*Continued.*

Matter.	Method.
II. Island, Strait, and Channel— (*a*) The word *island* means "*water-land*", viz., land set in, and surrounded by, water. Our country is a large island. Many smaller islands lie near this larger one, as the Isle of Wight. Many islands once belonged to the bigger land-masses near them. Thus England was *once* not an island; it was joined on to what is now called France. But the sea gradually came between and turned this land of ours into an island. Islands are constantly being made by the sea cutting off pieces of the larger masses of land. And, on the other hand, islands are being constantly washed to pieces.	II. (*a*) Represent an *island* to the class by building up in a saucer of water, a little structure of stones and sand, chalk, etc. Refer to the little islands (sand and mud-banks) in a river-bed in summer time. Show on a map of Europe (without naming any countries), that England is near larger masses of land; and that in time the sea would easily wash out the English Channel, or Strait of Dover. Draw on the blackboard the outline of the Isle of Wight. Make a model in sand of land in the form of a *peninsula*; then with water wash through the *isthmus* of this, and so make it into an island.

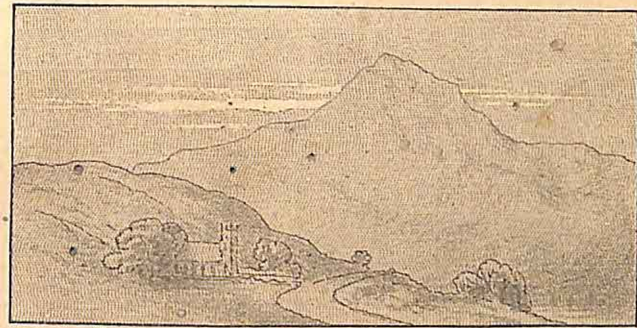
NOTES OF LESSONS—THE SEA AND ITS SHORES—*Continued.*

Matter.	Method.
When an island lies near the mainland, the narrow band of sea between the two is called:— (*b*) *Strait.*—This word means a *narrow strip* of water between two pieces of land, as the Menai Straits, and the strait between England and France. Some people say their shoes or slippers are too "*strait*", when they mean they are too "*narrow*": so this shows us that a strait is narrow. In time, as the waves keep washing the land away, the *strait* is turned into a *channel.*	(*b*) Point out the Strait of Dover and the English Channel, and explain that this *channel*, is like the strait, only wider: it also divides two lands but joins two seas. Show that a strait and a channel are always similar, the latter being larger than the former; and that they thus differ as a bay and gulf do. Make a *strait* in modelling clay, and convert it into a *channel.*
III. Peninsula and Isthmus— (*a*) One part of our country (Devon and Cornwall), is almost, but not quite, an island; it is a *peninsula*, which word means *almost an island.* The sea washes round three sides of this piece of land; but the fourth side is joined on to the mainland. (*b*) *Isthmus.*—When the joining part is narrow, it is called a *neck*, or *isthmus*, being like the neck joining the head to the body.	III. (*a*) Use clay to illustrate these two forms; also show the conversion of a *peninsula* into an island by turning the isthmus into a strait, and *vice versâ.* Also point out places named on map. Point out other peninsulas on the map of England, without giving names, as Carnarvonshire, Spurn Point, Portland Bill, and Kent. (*b*) Ask a boy in the class to come out, and point on map to an *isthmus*, but do not ask for its name.

82. NOTES OF LESSONS—LAND: A WALK IN THE COUNTRY.

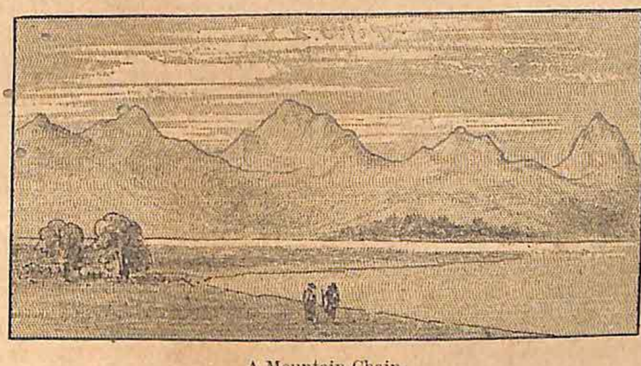
Apparatus.—Map of England, modelling clay, pictures of mountains, and a volcano.

Matter.	Method.
I. Introduction— We live and walk on the *land.* This is made up of *roads, fields, hills*, etc. Land is divided into *lowlands* and *highlands.*	I. Ask the children what they will be *walking on* when they go out of school. This is *land.* We cannot walk on water.
II. Plains, Tablelands— (*a*) *Plains.*—The middle of England is mostly low-land. This is a *plain*, or low, flat ground never rising high above the sea-level.	II. (*a*) Explain a *plain* by reference to the school *floor.* Enlarge this by extending the school *site* to the *play-ground*, and neighbouring level *ground near.* Point



A Mountain Peak.

A Mountain Group.



A Mountain Chain.

NOTES OF LESSONS—LAND: A WALK IN THE COUNTRY—*Continued.*

Matter.	Method.
The height of land is always measured above the sea, the sea being always at *one level.* (*b*) *Tableland.*—A *table-land* is also flat, but is *not low* like a plain; it is *flat* land *raised high*, as the top of a table is flat, but raised above the floor. Though flat generally, it is not altogether smooth and level like a table.	out to the class that a cricket ground is a small plain: and that it is so because of its *level* surface. (*b*) Use clay models to illustrate plain and tableland, also map of England. Illustrate "tableland" by the seat of a chair, and by a school table, harmonium top, etc., raised above the level of the school floor.
III. Hills— These are high parts of the land, but not *flat* high land.	III. Illustrate by any hills in the neighbourhood of the school.
IV. Mountains— (*a*) These are higher and more rocky and steep than hills. Mountains, except burning mountains, generally rise out of hilly ground, rarely out of low plains. *Mountains* must be more than 2000 feet above the sea; with less than that height, they are generally called *hills*. Some mountains are as much as five miles high, and have snow always on the tops. On such mountains it is always very *cold* at the tops, in summer as well as in winter. These white-topped mountains are very wonderful and beautiful. Many rivers have their origin in mountains.	IV. (*a*) Refer for illustration to any *local* heights, and make imaginary mountains out of these hills, by piling one on the top of the other, and by clay models. Do the same with wet sand moulded by a thimble to stand for *hills*, and by a glass tumbler to represent *mountains*. Show pictures in Reading books of mountains, cloud-topped, snow-laden; and volcanoes belching out smoke, ashes, and lava. Ask the class to notice that if we go to the top of any high *building*, or up in a *balloon*, it becomes colder and colder the higher we go up. Snow and hail are thus formed high up in the air where it is cold. Up in a balloon water freezes. It is just the same on the top of a mountain.
(*b*) The top of a mountain is called the *Peak or Summit*; the bottom is the *Base.*	(*b*) Make a clay mould of a mountain and point out on it the *Peak* and *Base.*
(*c*) Mountains arranged in a long line make a *Chain* or *Range*; so that each mountain is like a separate link in this chain. Others not in a line make a *Group*, or cluster of mountains.	(*c*) Arrange children on floor to represent each of these; also mould in clay a mountain and hill, to show their relative difference in height. Point out a *Chain* of mountains, and a *Group* on a Geographical Sheet.
(*d*) Mountains determine the direction of rivers, the outline of coast, etc. In England we should trace on the map the following:— (1) *Pennine Chain*, giving position, a few chief summits, and the rivers separated. (2) *Cumbrian Group.* (3) *North and South Downs.* (4) *Cornish and Devonian Heights.*	(*d*) Obtain from a map the position of mountains, plains, and hilly parts, and give a brief description of the surface. Thus in England there is the mountainous portion in the North-West and South-West, and a hilly region in the South-East. Our country is flat in most other parts, with a general slope from the West.

NOTES OF LESSONS—LAND: A WALK IN THE COUNTRY—*Continued.*

Matter.	Method.
(*c*) *Slope.*—This can be traced out on a map by means of the course of the rivers, which give the general slope: the reverse of this is the shorter, steeper side ("counter-slope"), with shorter and more rapid rivers.	(*c*) From the map we see the directions in which the rivers flow. These mountains and rivers should be pointed out on map, and divided according to direction into "Watersheds" and River Systems.
V. "Burning Mountains": Volcanoes— These are mostly sugar-loaf in shape, and are made of *ashes thrown* out, and molten rocks (*lava*) *poured* out, from the earth underneath. The top is often hollow, like a cup, and is called the *crater.* This often has steam and molten lava coming out of it; at such times the volcano is called *Active.* There are no *Active Volcanoes* in England now; they have all long since ceased to pour out their fiery contents. They are like sleeping children, whose bad tempers have quieted down.	V. Show pictures of an outbreak of a *volcano*: and describe such in a graphic *word-picture.* Make a clay model of a volcano: and name the parts of it. A little red ochre will represent *lava* streams on the sides of this; and a small fire in the hollow made on the top to represent the crater, will *interest* the children; excite their *imagination*; and strengthen their *memory.* Also show the class a piece of *pumice stone*: and tell them that this is the scum, or lighter "frothy" part of the molten lava.
I. Valleys— These mostly lie between mountains, at their bases. Such are called "*Mountain-Valleys*", and often have *Lakes* in them. These are hollows, filled in by water running down from the mountains in springs and streams, or by rivers, or melted snow. Others are "*River-Valleys*" with steep rocky, or stony sides, made by the rapid mountain torrents.	VI. Point out Mountain-Valleys in the Lake District of Cumberland, and show that there are many mountains there, but do not name these. Explain that the mountains bar up the way to the rivers; and so the *lakes* are formed, where elsewhere the water would run off into the sea. Point out on a map of England (without naming) a River Valley.

PART III.

STANDARD III.

Government Requirements.—"*Simple principles of classification of plants and animals. Substances used in the arts and manufactures. Phenomena of the earth and atmosphere.*"—*Revised Code. Schedule II. Class Subjects. Art.* 101 (*e*).

"*Thirty object lessons on the chief tribes of animals and their habits, on common plants and their growth; and on common unorganised substances and their properties.*"

"*It is intended that the instruction in Elementary Science shall be given mainly by experiment and illustration. If these subjects are taught by definition and verbal description, instead of by making the children exercise their own powers of observation, they will be worthless as means of education. The examinations by the Inspectors will be directed so as to elicit from the scholars, as far as possible in their own language, the ideas they have formed of what they have seen.*"—*Supplement to Schedule II. Alternative Course I.*

INTRODUCTION.

The teacher will note that the subjects of instruction in **Elementary Science** in this Standard fall under three chief heads—

I. **Natural History, or Zoology and Botany.**
II. **Common Things.**
III. **Phenomena of the Earth and its Atmosphere.**

The second head has been so admirably treated in Hassell's "**Common Things**", that for economy of space attention here has been confined to the first and third divisions.

These are presented for the first time, it is believed, in a copious **systematized** form, for the practical use of class-teachers. The crudest notions on the subject of "**Classification of Animals and Plants**" are prevalent among the youngest teachers, owing to the fact that their reading is almost entirely confined to brief selections from the ordinary reading books of articles on **animals.**

Some trouble, therefore, has been here taken to present the subject of Animals and Plants in a broader light, so far as their

principal divisions alone are concerned. But this has been done with as little reference to scientific nomenclature as was, perhaps, possible. In this standard, the Vertebrates alone have been dealt with, and only the most important Orders of the several Classes taken, as this subject will be continued in Standard IV.

Without these landmarks, it is felt that the young teacher could not properly teach even the very limited amount of information set down for the children themselves, in the actual "Notes of Lessons", and the "Specimen Lessons", here designed for their immediate benefit.

The teacher will also note, that the third item, "Phenomena of the Earth and Atmosphere", is a very wide and important subject. The author has felt that this could be well prepared for by the simple preliminary treatment of the subject which has been given in the preceding Parts I. and II. This method of early treatment has the advantage of clinching the teaching already given in Geography in Standards I. and II.; and of making it more practical, interesting, and inductively educative. The early lessons on the Common Rocks (clay, chalk, sandstone, etc.), and those on the Rivers and Oceans, etc., will thus have laid a foundation for what is now presented in a more advanced direction in Standard III., and for what will follow in a later stage.

83. THE WORLD AROUND US.

SPECIAL INFORMATION FOR THE TEACHER.

I. Natural History.—Natural History is properly that department of science which deals with all natural objects.

But a very brief examination of these shows us the necessity of dividing the matter by which we are surrounded on all sides into two great divisions:—

(1) The animate, or living, and
(2) The inanimate, or dead,
} Forms of matter.

II. Seeds, Eggs, and Fossils.—But there is the special case of seeds, eggs, and fossil remains of pre-existent animal and vegetable life. These, at first sight, seem all dead, having no power of moving about from place to place; or of increasing in size by the reception of food, or by growth; or of changing in structure or function according to the laws of development.

But the life of seeds and eggs is, nevertheless, real, though dormant. These objects are truly animate, in possessing life to be exhibited under favourable circumstances.

Fossil relics offer more difficulty still, since the parts preserved are the shelly coverings, scales, spines, and bony skeletons, which even in the living animal were dead, or formed material. They may, therefore, be classed among the inanimate if we recollect that they are the results, or products, of life.

III. Organic.—This classification serves, however, only as a starting-point; and is improved by dividing matter into:—

(1) The organic; and

(2) The inorganic.

By an organ is meant, an instrument, or means, by which some special function of life-work is performed. Thus, the mouth is an organ of speech; the hand of prehension; similarly the root is an organ of absorption of soluble matter from the soil; and the leaf an organ for the interchange of gases between the interior of the leaf and the outer atmosphere.

IV. The Organic.—The Organic world includes both animal and vegetable forms. These, in the higher divisions, have special instruments for special work; such as for the taking in of food, and for building it up into animal or vegetable structures.

The Inorganic world comprises all those forms of matter which neither as a whole, nor in separate parts, have any means or power of carrying on these functions of life.

84. THE ORGANIC AND INORGANIC.

SPECIAL INFORMATION FOR THE TEACHER.

There are so many differences between organic and inorganic substances, that it is necessary to set these forth in clearer outlines, and fuller detail.

I. Form.—(*a*) Inorganic bodies, as a lump of chalk, or a diamond, are either:—

(1) Without definite shape; or,

(2) Crystalline, that is, bounded by straight lines and by plane surfaces.

(*b*) Organic bodies, on the contrary, are mostly bounded by curved lines and curved surfaces; as in the outline and exterior surface of the human body, or of a growing plant.

II. Arrangement of Parts.—(*a*) Inorganic bodies are made of the same materials, and are of the same structure and texture throughout. Thus a lump of coal, or of chalk, is altogether coal or chalk, every one part being exactly like every other. As no

work is done by an inorganic body, so also there are no organs set aside for doing it.

(*b*) Organic bodies, in the higher divisions, are made up of parts differing in structure for the different tasks assigned them in the life of the plant or animal as a whole.

In the very lowest forms of animal or vegetable life there is no clear separation into organs; but the whole is an organ or organism. Thus, in the single cell of the yeast-plant, where the cell constitutes the plant, this can take in food, and reproduce its kind; which no form of the inorganic,—as a particle of gold, iron, etc.,—can do.

III. Mode of Increase.—(*a*) Inorganic bodies become larger by addition of similar matter from the outside; and this similar matter is laid down on the preceding; without itself or the part added to it undergoing any change in the process.

Thus, in chalk the increase consists of the successive deposits of fresh particles of chalk on the outside of those already deposited. Again, in crystals, as of common salt, the increase in size is brought about by regular additions to those already formed, the whole keeping its original form, though not its original size.

(*b*) Organic bodies increase by taking food from the outside, and turning it inside into vegetable or animal tissues. The materials thus received inside the body are assimilated, or made like the body into which they are received.

IV. Size and Shape.—(*a*) In Inorganic bodies there is no limit to the size of the object; a lump of chalk may be of any dimensions, as well as of any shape; and crystals may also be of any size, though not of any shape.

(*b*) In Organic bodies, on the contrary, there are certain limits of size, as well as limited variations of shape.

V. Internal Changes.—(*a*) As Inorganic bodies do no work, so also they undergo no internal waste. But life means work; and work means waste.

(*b*) But in Organic bodies the food taken in by plants and animals is not all used up for maintenance, or growth; otherwise a man would increase in proportion to the quantity of the food he received; and the same remark would apply, though not so thoroughly, to a plant. On the contrary, some of the food taken in is expended in repairing the waste due to work.

VI. Chemical Composition.—All matter can be resolved by the chemist into Elements. These are substances which are each all alike in nature and properties; and can be turned into no other simpler forms of matter than themselves. But these elements can

be combined together to form compounds, just as out of letters we can make words.

(*a*) In Inorganic substances we have :—

(1) Elements, as gold, oxygen, etc., and

(2) Compounds, made up of a small number of elements, as water, made up of hydrogen and oxygen (H_2O).

As a rule, inorganic bodies mainly consist only of two or three elements.

(*b*) But organic bodies generally have a larger number of elements combined together. Thus a piece of animal flesh contains carbon, nitrogen, oxygen, hydrogen, sulphur, and phosphorus. And these more numerous elements are also combined in more complicated ways, or in much more complex proportions, as starch ($C_6H_{10}O_5$).

"*An organic being is a microcosm—a little universe, formed of a host of self-propagating organisms, inconceivably minute, and numerous as the stars of heaven.*"—DARWIN.

85. ORGANIC AND INORGANIC BODIES.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction to Life.—If we take a potato and a pebble, we see that in some respects both look alike ; and yet in others they are very different. One is hard, while the other is soft. If the potato be cut open, it will be found to be juicy and wet ; but not so with the pebble, which will appear hard and dry.

II. Growing.—Now we will serve alike both the potato and the pebble ; and see what happens. We will set them in a flower-pot in the school in the same soil, and water them just in the same way. In a few days we examine if anything has occurred. Yes ! The potato has begun to grow. Some green leaves and a stalk have budded out of the potato. But nothing as yet has come from the pebble.

We leave them a few days more, and then take them both out of the ground. The stone is just the same as at first ; nothing in it has changed in the least. The potato is very different. The potato itself has begun to rot, but a root, stalk and leaves have come out of it. Now the potato has thus grown, because it has in it what we call life ; or it is alive. But the stone has not grown,

because it has no life. So we see that there are things that will grow, or that have life; and that there are also things that will not grow, or that have no life.

III. Living Bodies.—Besides vegetables, or plants, like potatoes, trees, grass, etc., there are other things on the earth which are also alive, and which seem even more alive than the former, since they can move about. These are Animals.

All these, and the plants, are different from the pebble in another way beside being alive while the minerals are dead.

IV. Organs.—Animals and plants are made up of different parts. There are the root, stem, branches, leaves, and flowers in plants; and in animals (ourselves included) the head, trunk, and limbs. A pebble, a bit of sandstone, or granite, etc., are not so made up of parts.

These parts of animals, or plants, we call Organs. Anything which has organs is called Organic: so the Organic World is the same as the Animal and Vegetable Kingdoms.

But we must have a name for the opposite, or the Mineral Kingdom. This we call the not-organic, or the Inorganic World.

Each of these different organs of a plant, or animal, has its own shape and form; it is built up in its own way; that is to say, it has its own structure. No one would mistake our eyes for our ears; or a root for a flower. And each organ also has its own work to do; the eyes are for seeing, and the ears for hearing; and the ears cannot see, nor the eyes, hear. So also in the plant, the root is for sucking up food from the soil; the stem is for spreading out the leaves, etc.

So we see, that just as a street organ is a musical instrument, or an instrument to make music,—so also all organs of plants and animals are instruments to do work with. This work is for the plant or animal itself, to keep it alive; or, it may be, to keep up the race.

V. Summary.—We thus learn that the things on the earth may be divided into very different classes, according to the way we look at them:—

(1) Solids, liquids, and gases. (*Vide infra.*)
(2) Metals and non-metals. (*Vide* Part I.)
(3) Organic and inorganic.

86. NOTES OF LESSONS—ORGANIC AND INORGANIC BODIES.

Matter.	Method.
I. Comparison of Organic and Inorganic Bodies— All bodies on the earth can be divided into *organic* (living), or *inorganic* (having no life):— (*a*) A *dog* lives; it can run, bark, see, eat, etc. (Animal.) (*b*) A *tree* lives, because it can grow, and produce leaves, flowers, etc. (Plant.) (*c*) A *stone* has no life, but remains always the same. (Mineral.) A *man*, like a dog, lives, he has organs to see, eat, hear, smell, etc. These organs do particular *work*, and anything that possesses organs is said to be *organic*, while those objects without organs are, as a rule, *inorganic*. We thus see that we can group the world around us as below:— 1. *Organic* { (*a*) *Animals.* (*b*) *Plants.* 2. *Inorganic* (*c*) *Minerals*, or 1. *Living* (animate). { (*a*) *Animal* kingdom. (*b*) *Vegetable* kingdom. 2. *Dead* (inanimate). { (*c*) *Mineral* kingdom.	I. Ask for things that a *dog* can do; and what *organs* enable it to do these. Show that *plants* live and have organs, by referring to potatoes, wheat, etc., growing; or show a root of the same, or diagram of it, and explain that this performs work. Subject a potato and a stone to the same treatment; place them in the ground, water them, etc., and note the difference after a few weeks. The potato is now *growing*; the stone is just the same as before. Give the word "*organ*" to the parts performing a *special work*; and ask for the various organs of a plant and of an animal. Refer to the statue of a man; why cannot such a *stone-man* eat, drink, etc.? (Because it has no *life*.) Ask for a list of bodies, and classify them as *organic*, or living; and *inorganic*, or dead; and write their names on the blackboard under those heads. Do the same under the three heads of animal, vegetable, and mineral. Then show that the former two belong to the previous organic list.
II. Higher and Lower Life— The more organs a body has, and the more each is set to do *one kind* of task only, the better it can get on in the world; or (*a*) Animals which have *many* organs have *higher* life. (*b*) Animals which have *few* organs have *lower* life. This is true of plants also. *Man* has the highest form of life on the earth, because his organs are the *most numerous*, and the *best*.	II. Show this difference by comparing a *man* and a *snail*. Explain to class that a penny whistle cannot produce as good music as the organ, because of this want of parts in the simpler instrument. Contrast also a large trade establishment, with a small shop with only one workman in it. Ask for some forms of (*a*) higher, and (*b*) of lower life, noticing in each what makes the difference between the two groups, to verify statements discussed in "Matter" column.
III. Animal Life— Whilst some animals have many more organs than others, most *animals* possess organs which *plants* do not. Animals possess organs which enable them to *feel*,	III. Ask for an animal with many, and one with few organs, and compare and contrast each with a *plant*. Can plants as a rule change their position? (No.) Animals can generally do so.

NOTES OF LESSONS—ORGANIC AND INORGANIC BODIES—*Continued.*

Matter.	Method.
and generally to *move*. Some animals,—such as sea anemones,—have only organs to feel, move, and get food with, but are without those of *sight, sound, hearing*, etc. Animals of a higher form of life can utter sounds, hear, see, etc.; or they have *special senses*.	Show a picture of a sea anemone, or a jelly-fish; or the animals themselves, on the sea-coast; or refer to a snail. All these have lower life; and are without some of our *organs of sense*. But they can all *move* about, whilst a *plant* is rooted to one spot.
IV. Plant Life— No plant has the higher form of life of an animal,—possessing only two great groups of organs, the *root*, and *stem* with what belong to these. The *root* is to push underground to feed the plant; the *stem* to bear flowers, leaves, etc., and to allow food to pass up to the top part of plant; the *leaves* are to take in food from the air. Some plants, like many orchids, have no proper roots; but live on moisture and other matters in the air. But, on the other hand, some plants (pitcher-plants, etc.), trap insects and use them for food.	IV. How have plants a lower form of life than animals? (They have only two great sets of organs.) Ask for the work of these different organs, and compare them with those of man. Draw a diagram of a *typical* plant on the blackboard, and show how each organ in it does its own special work. Tell class that the orchids mostly grown in *hot-houses* in England come from hot countries, where they grow *wild* on the trunks of trees, instead of on the ground. Draw a diagram of a pitcher-plant, or show a picture of one.

87. DIFFERENCES OF PLANTS AND ANIMALS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Introduction.—It has been well remarked in this connection, that there is no hard and fast line,—no natural line of demarcation,—between day and night. Nature always works by insensible gradations; there is no fixed line, and there are no leaps. It is easy to tell an ox from the grass upon which it feeds; but it is not easy to tell the lowest animal from the lowest vegetable forms of life. The following are the chief differences between plants and animals.

II. Form.—The general shape and outline of plants and animals is different. The root, stem, and branches of an oak are as different as can be from the outline of the ox feeding beneath it. But some so-called "seaweeds" found on the seashore cast up by the waves, or growing in rock-pools, are really animals. Many of these, however, are so wonderfully like vegetables that they are

called "Animal-plants" (Zoophytes), and they are regarded as plants by most seaside visitors.

III. Locomotion.—Secondly, animals generally have the power of **locomotion**; but plants are mostly fixed to one spot. But here many **exceptions** to the rule may be found, both in plants and animals :—

(*a*) Many of the lowest plants can move about **as a whole** in water.

(*b*) Some plants have **leaves** and others flowers which can close on insects settling on them.

(*c*) Others have leaves which can bend over on insects, etc., placed on them, and can not only entrap, but also digest them.

IV. Food.—As a rule, **plants** feed on the **inorganic**; and **animals** on the **organic**, either vegetable or animal.

Plants are thus the great "**manufacturers**" of Nature; and animals the "**consumers**" of the "manufactured articles".

Animals and plants alike take their food from the **outside** into the **inside** of their bodies. But animals have mostly internal organs of digestion, or something like these, in the shape of a stomach, etc. ; and plants are without these.

V. Structure.—The **results** of food taken in by plants are leaves, stems, flowers, and roots. In **animals** the food becomes muscle, nerves, bones, etc.

THE ANIMAL KINGDOM.

88. CLASSIFICATION OF ANIMALS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Divisions.—Most of the larger and best known animals agree in having an **internal skeleton**; such are **Mammals** (horse, tiger, etc.), **Birds, Reptiles,** and **Fishes.**

These make up the **Division** of the **Backboned** Animals (**Vertebrates**). But the bee, grasshopper, silkworm, etc., have no internal bony skeleton. These make another **Division**, viz.:—Animals **without backbones (Invertebrates**).

All animals come under one of these two **Divisions.**

II. Animals with Backbones (Vertebrates).—From com-

mon specimens, such as a rabbit, fowl, snake, or haddock, we see that the backbone is made up of :—

(1) Many separate pieces, or joints (vertebrae) turning upon each other.

(2) This chain of bones encloses a long canal, in which is the spinal cord proceeding from the brain.

(3) The limbs (legs, arms, ribs, wings, etc.) are more or less connected with the backbone.

III. Differences in Vertebrates.—Though the backboned animals agree in having a backbone, yet their structure otherwise differs with their modes of life, habits, places of abode, etc. In the Mammals the joints of the backbone are connected by elastic pads of very strong gristle. Much strength is often required by these animals ; and, therefore, they frequently have heavy limbs, and a very strong framework attached to a strong backbone.

Freedom of movement is also necessary. In Birds the movement of the vertebrae is not so necessary as in Mammals, except in the neck ; in birds, therefore, the vertebrae are more united, to form a firm basis for the attachment of the strong muscles required for flight. Some birds have long vertebrae in the neck, as in the swan ; others short ones, as in the sparrow :—the length depending on how and where the food is obtained.

In Fishes these vertebral joints are cup-shaped on both faces ; and the hollows filled with a gelatinous fluid. This gives very free movement. Fishes live in water, which supports the weight of the body ; so they need flexibility rather than strength.

IV. Animals without Backbones (Invertebrates).—Most of the smallest animals (the beetle, bee, wasp, silkworm, worm, shrimp, etc.) have no backbones. Being smaller, they require none ; nor any framework to support so small and light a body. The part behind the head of all insects, in all stages, is made up of thirteen segments, with a flexible skin between each to give free motion corresponding to that secured by the vertebrae of the Vertebrates.

89. BACKBONED ANIMALS—VERTEBRATES.

SPECIAL INFORMATION FOR THE TEACHER.

I. Differences among Vertebrates.—Though all agree in having a backbone, the vertebrates otherwise differ much ; as seen in comparing a horse, eagle, snake, and herring.

II. Their Mode of Progression differs; as may be seen from the following brief tabular statement:—

(*a*) **Walking.**	(*b*) **Flying.**	(*c*) **Swimming.**	(*d*) **Creeping.**
Horse	Sparrow.	Duck.	Snake.
Cow.	Eagle.	Swan.	Serpent.
Crab.	Thrush.	Herring.	Blindworm.
Cat.	Pigeon.	Codfish.	Lizard.

This kind of division is thus seen to be a most **imperfect** one, as under the head of Swimming Animals we have such widely different classes, as **Birds** (duck and swan) and **Fishes** (herring and codfish).

(*a*) **Walking Animals.**—But animals that all **walk** may differ widely in **other** points; compare a crab and a horse, which are in different Divisions as well as in different Classes.

We, therefore, classify into the same group those animals which are alike in the greatest number of particulars, according to certain laws.

Thus the dog, cat, lion, tiger, etc., are alike in belonging to the same Division (Vertebrates), to the same Class (Mammals), and to the same Order (Carnivora).

We now proceed to point out the most distinctive marks or characteristics of the great **Classes** of animals.

Class I. Mammals.

These agree—

(1) **In having their covering** of hair, wool, or fur.

(2) In feeding their young on **milk.**

(3) In having **warm** blood.

(4) In breathing by **lungs.**

The crab differs from this group in all four respects; although it agrees with them all in walking.

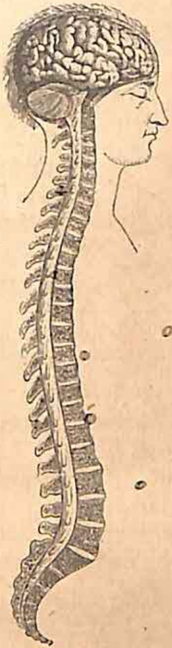
We now, therefore, drop the name of "Walking Animals", and take a new one, viz., "**Mammals**".

(*b*) **Flying Animals** also widely differ in other respects than their common mode of progression. A bat is unlike a sparrow, though both fly and have backbones. But the eagle, sparrow, thrush, etc., agree with the Mammals in (3) and (4) of the preceding paragraph, but differ from them in (1) and (2). But these **birds** all agree together in themselves, in the points (1), (2), (3), (4), (5), enumerated below:—

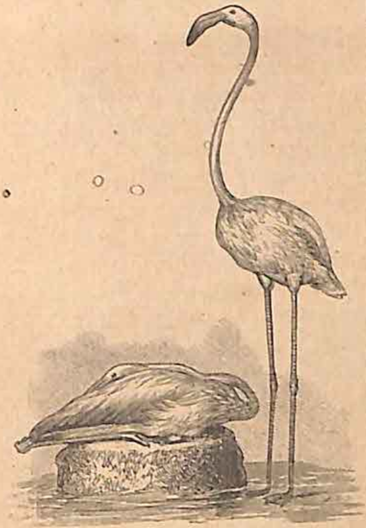
Class II. Birds.

(1) These have a **covering** of feathers.

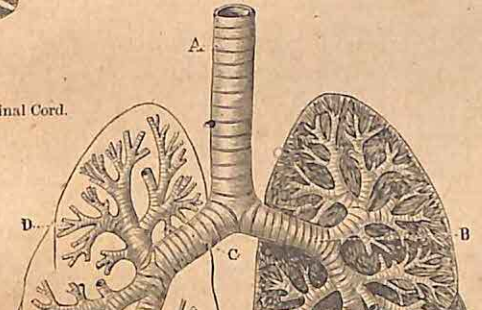
(2) They do **not** feed their young with **milk.**



Brain and Spinal Cord.



Flamingo, with Female on nest.



Bronchial Tubes.

A, Windpipe. B, Left Bronchus. C, Right Bronchus. D, Smaller Bronchial Tubes.

(3) They lay **eggs.**

(4) They have **warm** bodies.

(5) They breathe by **lungs.**

We therefore now drop the name of "Flying Animals" and give the name of "**Birds**" to all animals alike in the above five points, or in most of them.

There are thus two points of difference from the preceding class :—(1) Their covering, and (2) Not suckling their young.

(*c*) **The Swimming Animals.**—Excluding the swimming **birds** (duck, swan, etc.), this group leaves us the herring, codfish, etc.

Class III. Reptiles.

(*d*) **The Creeping Animals.**—There is however another Class with backbones, of which the snake is a type, which agree ;—

(1) In having their **covering** of scales, or horny plates.

(2) In laying **eggs.**

(3) In having nearly **cold** blood.

(4) In breathing by **lungs, or gills,** according as they live on land or in water ; or according to their age or development (the **true** reptiles having always lungs).

(5) In mostly **creeping.**

This Class we call **Reptiles,** and it differs from the preceding in three points :—

(1) In having horny **plates** or **scales.**

(2) In generally breathing by **lungs.**

(3) In **crawling** or **creeping** (frequently).

IV. Summary.—**Summing** up the preceding, we get :—

Animals are, { I. Those **with** backbones (**Vertebrates**).
II. Those **without** backbones (**Invertebrates**).

Class IV. Fishes.

These are alike :—

(1) In having their **covering** of scales.

(2) In **not** feeding their young with **milk.**

(3) In laying **eggs.**

(4) In having nearly **cold** blood.

(5) In breathing by **gills.**

There are thus three points of difference from the preceding :—(1) **Covering.** (4) **Cold** bodies. (5) **Gills.**

We therefore now drop the name of "Swimming Class" for these, and take the name of **Fishes** instead.

I. BACKBONED ANIMALS.

Class I.—Mammals.—Characteristics :—

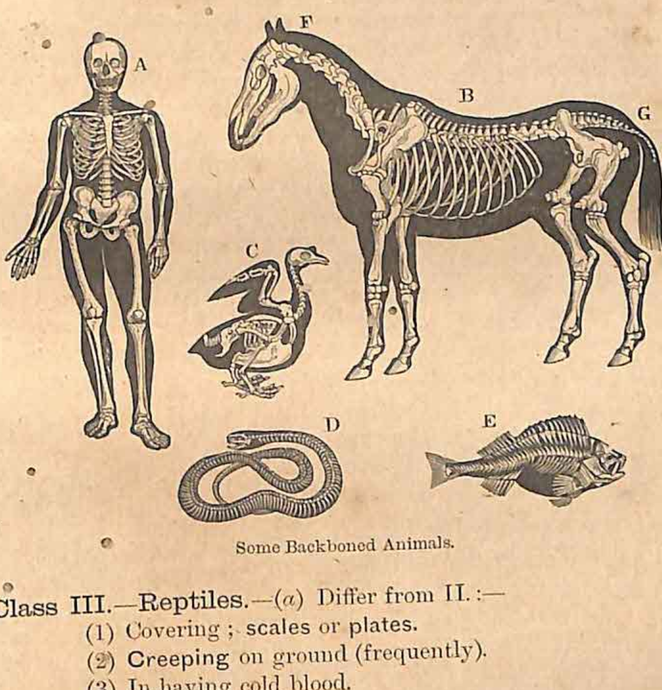
(1) The covering is of hair, fur, or wool.
(2) The young feed on milk.
(3) They have warm blood.
(4) Respiration ; by lungs.

Class II.—Birds.—(*a*) Differ from I.:—

(1) Covering ; of feathers.
(2) Young ; hatched from eggs.

(*b*) Agree with I.:—

(1) In having warm blood.
(2) In breathing by lungs.



Some Backboned Animals.

Class III.—Reptiles.—(*a*) Differ from II. :—

(1) Covering ; scales or plates.
(2) Creeping on ground (frequently).
(3) In having cold blood.

(*b*) Agree with II. :—

In their young not feeding on milk.

(*c*) Differ from I. and II. :—

In their breathing by lungs (but some by gills).

Class IV.—Fishes.—(*a*) Differ from II.:—

(1) In having a covering of scales.

(2) In having cold blood.

(3) In always breathing by gills.

(*b*) Agree with II. and III. in laying eggs.

90. MAMMALS.

FURTHER INFORMATION FOR THE TEACHER.

I. **The Class.**—We have seen that the great group of the "Animal Kingdom" is made up of "Divisions". Of these the largest, and most important, is that of the Backboned animals, or the Vertebrates. These all have a skull, an inside skeleton, and a backbone. But they differ from each other very much in other respects; so a further division is made into Classes. The largest of these is that of the Mammals; the others are Birds, Reptiles (and Amphibia), and Fishes.

II. **Class I.—Mammals.**—These have warm blood; do not lay eggs; suckle their young; and are covered with hair (at some period of their lives), wool or fur. They also mostly have four limbs, in two pairs, viz., legs; or legs and arms.

III. **Differences.**—But they differ from each other very much in other respects, especially in:—

(*a*) The number of hands.

(*b*) Their food.

(*c*) Modes of locomotion (progression).

(*d*) Kinds of teeth.

(*e*) Modes of digesting their food.

(*f*) Thickness of skin.

(*g*) Whether or not they have pouches, in which to shelter their infant young.

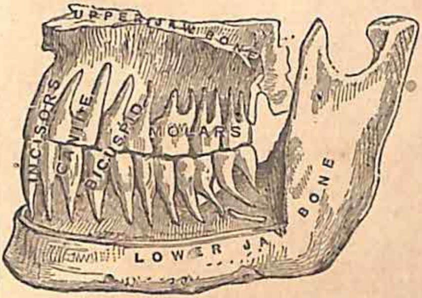
IV. **Orders.**—We thus get, according to these Differences, many Orders. These do not differ in one respect alone throughout, but according to some one of the several items set down above (*a*)-(*g*).

Among the principal Orders of Mammals are the following:—

(1) Two-handed, as man, who thus stands at the top of the list.

(2) Four-handed, as in monkeys, apes, etc., who use the hinder as well as the fore-feet, in climbing trees, etc.

(3) Flesh-eaters, Carnivorous animals (Carnivora), or beasts of prey. These are a most important Order; and two types of these



Human Teeth.


Skull of Rodent (Marmot).


Skull of Carnivorous Animal (Cat).


Skull of Ruminant (Sheep)


Skull of Thick-skinned Animal (Horse).


Skull of Toothless Animal (Great Ant-eater).

have been already given in detail (the cat and the dog), and their wild representatives, the tiger and lion, etc., in Standard II.

The Order includes (*a*) **Insect-eaters**, as the mole and hedgehog.

(*b*) **Sole-walkers**, as the bear, walking on the **soles** of the feet.

(*c*) **Toe-walkers**, as cat, dog, lion, etc., walking on the **toes**.

(*d*) **Marine Mammals**, as the whale, seal, walrus, or sea-lion ; or those animal feeders living in the **sea**.

(4) **Gnawers** or **Rodents**, as the rat, mouse, beaver, rabbit, hare, etc., which have the front, or **incisor** teeth, largely developed, and largely used.

(5) **Cud-chewers**, **Ruminants**, as the cow, sheep, deer, and camel ; or those animals that chew their food after it has been **previously** swallowed. These are the "grazing animals" generally, but not including the horse, ass, etc.

(6) **Thick-skinned**, as the elephant, hippopotamus, horse, etc., with a skin generally of great thickness, especially in the elephant. Sometimes the horse is removed out of this group, and put with the "**solid-hoofed**" animals.

(7) **Toothless**, as the sloth and ant-eater, which have no teeth generally.

(8) **Pouched**, as the kangaroo, or those animals which have a pouch into which the young are placed when first born.

All these **Orders** will have to be here represented by the animals already given :—

(1) The **Cat** and **Dog** ; **carnivorous.**
(2) The **Horse** ; **thick-skinned** ; or solid-hoofed ; and
(3) The **Cow** ; **cud-chewer**, or ruminant.

The mode of treatment which has been accorded to these will suggest to the teacher how to prepare "**Notes of Lessons**", and "**Special Information**" for himself for the representatives of the other less important remaining Orders of the Mammals. The sources from which to draw up "**Special Information for the Teacher**", when this department of the Syllabus is alone going to be taken up for the Class Subject, should include the following :—

(1) Wood's "Natural History".
(2) Wood's "Natural History Readers".
(3) Hassell's "Common Things".
(4) Hassell's "Familiar Objects".
(5) Nicholson's "Zoology".
(6) Reading books of various publishers.
(7) Blackie's "Elementary Science Readers", IV., V., VI., (Rev. J. G. Wood).

91. NOTES OF LESSONS—BIRDS: GENERAL CHARACTERISTICS.

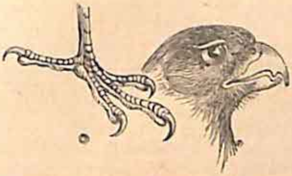
(FIRST SKETCH.)

Apparatus.—Pictures of birds' heads, beaks, and claws; a live or stuffed canary, or other bird: birds' claws preserved.

Matter.	Method.
I. Introduction— Birds differ much from previous animals (mammals) in *locomotion*: they *fly*. Their *food*, too, differs, and is obtained in different ways. Hence their *structure*, too, is different, and is modified to suit these different modes of life.	I. Show a canary, and compare it with previous animals in means of *locomotion*; also with a child's. Get from class the kinds of *food*, and modes of *obtaining* it, used by domestic birds (canary and fowls). Show that the *structure* of birds is fitted to their habits, in their having wings and feathers.
II. Skeleton— Birds fly, so must not be heavy; their large bones are therefore *hollow*, and filled with *air*; not like ours solid, or filled with marrow.	II. Inflate a bladder and show its *lightness*: and refer to balloon, which is large, but not too heavy to rise. Now apply this lightness to birds.
(*a*) *Breathing—Supply of Air.*—The air passes into the lungs, and also into the hollow bones of birds. The chest is like a pair of bellows; the back and front, the boards; and the throat, the nozzle. In many birds air also passes under the skin and flesh. This plentiful supply of air enables songsters to sing long and loudly, and generates heat for the body, as air does when applied to a fire in a grate. The male bird is the singer, where there is song at all.	(*a*) Take a deep breath, to show class that in breathing lung-space can be enlarged. Refer back to horses and dogs needing great lung- or air-space, that they may run swiftly and far. Show that when a fire has plenty of air or draught it burns well; and cover a candle with glass tumbler, to show that it goes out for want of air. Remind children that skylarks sing and soar at the same time: and repeat Shelley's:— "And singing still dost soar, And soaring ever singest."
(*b*) *Beaks.*—The shapes of these depend on the food. A bird has no *teeth*, nor soft lips; the beak is made of horn like our nails. If the food is *flesh* seized by the claws, and torn by the beak, the latter (like the tearing teeth of a dog) is *curved*, as in the eagle. Hard *seeds* require crushing: for this the beak is *hard* and *straight*, as in the sparrow. Birds feeding on soft *worms* got from the ground have generally long and *thin* beaks, as in the snipe.	(*b*) Draw different shapes of *beaks* on blackboard, and ask for their different uses, and to what kinds of birds they belong. Why do birds need no teeth nor lips? (They swallow their food whole.) Ask for the names of different birds of prey (owl, hawk, etc.), and make drawings on the blackboard of their beaks. Why do birds feeding on worms need long thin beaks? (For burrowing in the ground, etc.) Remind class that such birds often follow the plough at work, and thus obtain their food from the soil with less effort of their own.

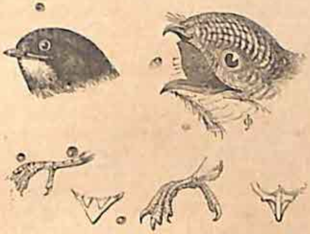
NOTES OF LESSONS—BIRDS: GENERAL CHARACTERISTICS—*Continued.*

Matter.	Method.
The general method of *drinking* is to take a few drops of water into the beak, raise the head, and allow the water to run down the throat.	Ask class for the way they have seen a canary take *water* from its glass. Point out that the swallow catches up water during its flight over ponds, etc.
(*c*) *Tongue.*—This is adapted to the obtaining, and holding food, rather than to tasting. Some birds, as the *pelican*, have no tongues. The *parrot* holds hard substances against the upper beak with its tongue, while the lower bites. The *woodpecker's* tongue is very long, and covered with bristles pointing backwards, for collecting and holding insects from the bark of trees. Many birds have the tongue covered with a hard horny substance.	(*c*) Point out that the *tongue* in birds is too *hard* to be an organ of taste. Show that the tongue, like other organs, is variously *modified* to various *uses*, and compare with those of cat, dog, cow, and horse. Get from the class as many of these uses of the tongue as possible, and then show the adaptation of the tongues to these uses in the case of a few well-known birds.
(*d*) *The Neck* of a bird is in proportion to its length of *legs*, and to the height of its body. All parts of the body can be reached by the bill.	(*d*) Get from the class why waders generally have long *legs* and long *necks*, and why sparrows have short necks and short legs. (See flamingo, stork, etc.) Compare with the necks of the giraffe and pig.
(*e*) *Legs and Wings.*—(1) *Legs.* A bird has two legs, with toes and sharp claws at the ends of these. The leg is formed of three parts, as in preceding animals, but when bent the toes are drawn together. A hen in *walking* at each step closes the toes, when the foot is lifted from the ground. In *perching*, the body-weight bends the legs, and draws the toes round the perch. The percher cannot fall until it stands to fly away: so it does not fall off its perch when asleep.	(*e*) (1) Draw enlarged diagram of a bird's leg. Compare with a child's. The teacher should show the action of the hen in walking, by his own hand, spreading out the fingers when flat on the desk, and closing them when lifted. Do the same with the hand clasping a round ruler, to show the action of a bird's toes and claws. Remind the class that some birds do not use their legs for walking, as the swallow.
Birds obtaining their food by means of their feet have very long ones; and also claws sharply *curved* like the beak, as in the eagle and other birds of prey. Those getting food from water, unless they *swim*, have long legs for *wading*, as the heron and stork. These have corresponding length of neck, to enable them to reach down to the water.	Point out that the parts are all suited to different kinds of *work*. Ask for names of birds obtaining food by the *feet*. Why should they have strong beaks, as well as feet? (To tear live food, etc.) What food does a stork feed on? (Frogs, fish, etc.) Ask for any other birds that feed on fish, etc., and have long necks and legs.
Birds that swim to their food have their feet broad and *webbed* like oars, to paddle with, as in ducks. This gives a large surface	Draw a diagram of the web-foot of a swimming bird. Notice the likeness to an oar. A boy swimming similarly keeps his fingers close together.



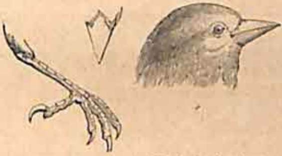
Head and Foot of Raptores (Birds of Prey).

Foot of Perching Bird.

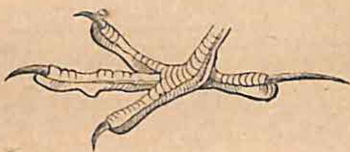


Head, Foot, and Bill of Fissirostres (Cloven-jawed).

Foot of Swift (one of the Fissirostres).



Head, Foot, and Bill of Conirostres (Cone-billed Perchers).

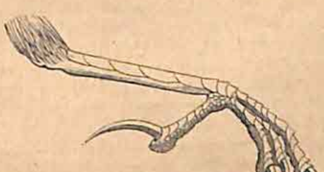


Foot of Skylark (one of the Conirostres).

Heads and Feet of Anseridæ (Web-footed).

Heads of Tenuirostres (Slender-billed).

Head of Dentirostres (Tooth-billed).



Foot of Titlark (one of the Dentirostres).

NOTES OF LESSONS—BIRDS: GENERAL CHARACTERISTICS—*Continued.*

Matter.	Method.
to act on the water, like the broad blade of the oar of a canoe, to increase the power of locomotion (progression).	How does the swallow obtain food? (Flying in the air.) Notice the strength of the swallow's wing.
(2) *Wings.*—The front limbs are wings, corresponding in *structure* to our arms, and to the fore-legs of a horse, dog, etc. But their *use* (function) is different. We have hands to lay hold of food, but the bird flies to its food; hence it has wings instead of arms and hands.	(2) Show a bird's *wing*, and point out how it can be made to spread, and so sustain the bird's weight in the air. The teacher should imitate the action of the wings by moving his arms up and down. Are feathers heavy? (No.) Show how well adapted they are to assist to make a body light: fur, hair, wool, etc., would be too heavy.
These are covered with *feathers*, and spread out like a fan. Feathers cover all the body like a blanket. They are bad conductors of heat, and so retain the great body-heat generated by food and air, and allow the temperature of the bird to remain high, and are thus very useful in the winter. Birds have mostly no feathers on the feet, nor on the lower part of the legs.	A blanket keeps us warmer than a sheet, by not letting our heat escape, and feathers are warmer than wool even. How do birds obtain a new coat? (By "moulting".) When does this happen? (In autumn.) Show why birds hop about in wet and dirty places. (To keep their feathers from becoming wet and soiled.) Refer to the wretched draggled appearance of a fowl caught in the rain, and contrast with a duck or other swimming bird.
III. Colours— These are very varied: the *male* being generally gayer and brighter than the female. The canary is one of the best singers among brightly coloured birds; generally the gayer the colour, the less the singing power.	III. Enquire what are the *colours* of the commonest kinds of English birds, such as the skylark, linnet, goldfinch, thrush, and blackbird; and compare with those of the parrot, the bird of Paradise, and other brilliant foreign birds, etc.
IV. Nests— Most birds use nests in which to *lay eggs*, and from which the young are hatched. Eggs vary in colour and size; but all are alike inside in consisting of white and yolk.	IV. Ask where the *nests* of sparrows, linnets, thrushes, hedge-sparrows, crows, etc., are severally built, and what they are made of; and how the place of nesting suits the habits of the builders.

92. NOTES OF LESSONS—ORDERS OF BIRDS.

(SECOND SKETCH.)

Matter.	Method.
I. Introduction— Some parts are more developed in some birds than in others. As we divide children into *classes*, so	I. Write down a list of birds from children's dictation, and classify these according to their beaks and talons, or their modes of

NOTES OF LESSONS—ORDERS OF BIRDS—*Continued.*

Matter.	Method.
we divide birds into "*Orders*", placing together those with most points in common.	life, the places they frequent, or their food, to get a few "*Orders*" from the children themselves.
II. Birds of Prey— *Type*: *Eagle.*—The name of the Order denotes the mode of life, which is dependant on living prey for food. Their *structure* is fitted for this, in having strong "talons" (*claws*), for striking and killing prey. The *beak* is only used for holding, tearing and eating food, consisting of birds, hares, rabbits, lambs, etc. With small prey the shock of being struck almost kills: but with lambs, etc., the prey is borne alive to the eyrie to be there torn to pieces; and so it must be firmly seized. The *leg*-muscles are very strong, and the toes drawn; when the legs are bent the claws protrude, and are driven deep into the prey, and are not easily withdrawn till the leg is straightened.	II. Show a picture of an eagle, and compare this bird with a canary, etc. Notice the large size and strength of the *beak* and *claws*. Show a picture (from a reading book) of an eagle carrying off a lamb or a child, to illustrate its strength. Where is the nest built? (On rocks, etc., generally in inaccessible places.) Refer the children for comparison to the feet of the lion, cat, tiger, etc. In all these, the act of striking projects the claws. Why do the claws or talons of birds of prey need to be hooked? (To hold the prey firmly.) Compare these with a lion's canine teeth, and show that both are for the same purpose, and are hence similar in form or structure.
(*a*) *Wings.*—To bear up this load, and to enable them to carry away the heavy weights of their prey, the birds must also have broad and strong *wings*.	(*a*) Point out need of these two qualities in the eagle's wings, and compare them with the long and narrow wings of swift birds with little weight to carry, as in the swallow.
(*b*) *The Beak.*—The food is torn by the curved beak; this is a prominent feature of all birds of prey.	(*b*) What kind of a *beak* does the bird of prey need to hold and tear flesh? (Curved and strong.) Compare the *beak* with the teeth of a dog, etc. Notice the difference in the beaks of the eagle and canary.
(*c*) *The Nest.*—The eagle builds a rude nest on rocks in mountainous districts; and is rarely seen in England. As it is destructive to flocks, man destroys it, and so it is most found in uninhabited districts.	(*c*) Describe the *nest*, made of branches, grass, etc.; very dirty; many bones about; and strong smell. Why does man kill the eagle? (To preserve his lambs, etc.) Name some country where it is still found. (Scotland.)
III. Cloven-Jawed— *Type*: *The Swallow.*—This is not a bird of prey, so it does not require a powerful hooked beak, nor strong, sharp, curved talons. It feeds on *insects*. These have often rapid flight, and little weight. The swallow, therefore, must also have a rapid flight; and for this, long *narrow, pointed,*	III. Show a picture of a *swallow*, and compare its build, size, claws, bill, etc., with those of an eagle. Notice particularly the long forked *tail*, for rapid turning; and (in the summer) with what ease it can fly and turn, coming close to us, and then sharply darting aside. Explain how the tail acts like the rudder of a boat. Compare with the tail of a fish. Compare

NOTES OF LESSONS—ORDERS OF BIRDS—*Continued.*

Matter.	Method.
wings. The wings are strongly developed, as food is caught in flight. It must also rapidly wheel to alter its course; hence, the *forked tail*, which opens or closes as required, and acts as a rudder. The tail is nearly half the length of the entire bird. It also has a very wide, deep, gaping *mouth*, whence its name.	the speed of a long, narrow, racing boat, with wider ones; also *narrow*-chested race-horse, with *broad*-chested cart horse. Notice the gaping mouth, better fitted for insect capture than a narrower one.
(*a*) Living on the wing, its *legs* are not strong, but short and thin. The four toes all point forward, and the *claws* are bent and sharp, to run up a wall to its nest. It drinks and collects nest-materials on the wing.	(*a*) Compare the swallow's *legs* with an eagle's and stork's: short, claws hooked for holding purposes. Say where its nest is built. Show that the claws must be hooked for it to get into the nest.
(*b*) It is a "*passage-bird*", coming here in April, and leaving us in September, living with us when there is plenty of insect food in the air. The commonest kinds are the house and sand-martin, and swift.	(*b*) Why do *passage-birds* not stop with us all the year? (For lack of food in cold weather.) Show pictures of the swallow, house-martin, sand-martin, and swift, and of the sand-martin's home in a sandy wall, or the side of a sandstone quarry.
IV. Cone-Billed— *Type*: *Sparrow.*—This order differs from the preceding in *structure*, and this on account of its different *food*. It feeds on grubs, worms, and caterpillars, thus keeping down insect pests; and also on grains, pease, and fruits, and small seeds; and at times on bread. The *wings*, therefore, are not so strongly developed as in preceding order, Cloven-billed birds, but shorter and weaker; and still weaker than in the birds of prey. The *tail*, too, is not so much used for steering; and so is shorter.	IV. Compare the sparrow with the swallow and eagle, especially in *wings*, *beak*, and *tail*. Ask the advantages of these differences in *structure*. Draw a cone laid on its side with line down centre, roughly to represent the shape of bill. The food of this order of birds, like that of young children, must be soft. Of what use are sparrows? (They check the ravages of insects.) Point out that they often do a great deal of damage to crops by eating seed-grain. Where is the sparrow's nest built? (Under eaves, and in any suitable cavity.)
(*a*) It walks more than the swallow, and also *perches*. Its *legs*, therefore, are stronger, and its *toes* arranged differently, three in front and one behind, as in all perchers, to clasp branches more firmly.	(*a*) Notice the different arrangement of the sparrow's *toes* for perching purposes; and compare with those of the swallow. Remind class that different orders of birds differ very much in their *feet*, as in swimmers (web-feet), runners (two toes in front and one behind), etc.
(*b*) Its *bill* is short to give strength; hard, broad at base, and gradually tapering to tip, or cone-shaped; this names the Order (Wedge-billed). When young the	(*b*) Compare a sparrow's *bill* with a *wedge*; in shape and use. Ask the children what they have seen sparrows collecting as *food* for their young from the *fields*. Refer to "sparrow-

NOTES OF LESSONS—ORDERS OF BIRDS—*Continued.*

Matter.	Method.
beaks are soft, to eat soft food, grubs, worms, and caterpillars. The mother bird brings food to her young every ten minutes, for seven hours a day; the young eat on an average two hundred caterpillars a day. Hence the use of sparrows to gardeners.	clubs" for destroying sparrows: and their use and abuse. Sparrows are useful to protect crops from insects; they are injurious in themselves eating the ripening corn crops. Remind the class that in *towns* they depend for food largely on scraps got from man; and that thus sparrows follow man almost wherever he migrates.
V. Web-Footed— *Type*: *Duck.*—This is a water bird; its food is obtained thence, so it has *webbed* feet, and *short* legs, for swimming. These legs serve like the oars in a boat to move the bird through the water.	V. Ask class to name other web-footed birds. Distinguish between *swimmers* and *waders*, and show the advantage of web feet and short legs, with long toes in one; and of the long legs in the other.
(*a*) *Shape.*—This is like a boat for floating and swimming, and is to be found in all swimmers.	(*a*) Point out the resemblance in *shape* between duck and other water fowl (rounded body, tapering to stern). Compare the walking on land with that of the swan.
(*b*) *Legs.*—These are set far back, hence its ugly waddle on the land. The *toes* are long, and connected by skin, hence name, "*web-footed*". When the foot is drawn forward, the web folds, and the toes come close together, and so offer little resistance to the water. With the back stroke the toes open out. Compare men rowing and feathering oars.	(*b*) Show also the advantage in progression through the water of the legs being set back. Explain the meaning of "feathering" an oar, and compare with the up-stroke of the wings in a bird's flight. In both cases resistance in moving through the water (or air) is aimed at.
(*c*) *Beak.*—This is flat, broad, hardest at the tip. The upper *jaw* has many projections, like the teeth of a comb; but pointing backwards. The lower has grooves into which the upper projections fit. This arrangement acts as a *filter* to strain out mud, etc. The *food* consists of aquatic insects, spawn, worms, etc., from soft mud. The *mouth* opens and rapidly closes, and the water and mud are strained off, and the food left behind is chosen by the *tongue*, which is very sensitive to touch, having plenty of *nerves*. It is large, fleshy, and soft, with a still softer fringe. *Web-footed birds* are found in flocks wild, in lake and marshy districts. The wings are strong and often used for long flights.	(*c*) Ask class what use it is to the duck to have the tip of the *beak* hard, in finding food at the bottom of water. Explain the action of ducks "*filtering*" mud. Refer to the mode of life, and the kind of food eaten, by many aquatic birds; and where found, and therefore the necessity of this separating act of filtering. Refer to the mode of capturing wild ducks by decoys in the Fen districts; and to their great numbers before the land there was drained. Explain that these ducks come to this district because of the abundance of aquatic *food* found there. Explain to class that it is by the *nerves* that animals feel, etc. The duck has to get its food from the bottom of the water, so *feels* for it.

NOTES OF LESSONS—ORDERS OF BIRDS—*Continued.*

Matter.	Method.
(*d*) *The plumage* is glossy and waterproof. Hence the saying, "water running off a duck's back". The female (duck) has not such beautiful plumage as the male (drake): this is generally the case with birds.	(*d*) Contrast the *plumage* of the drake and of the duck; illustrate by the bright plumage of other male birds (peacock), and sober tints of female (pea-hen). Tell the class that male and female (and singing and songless) birds, as in goldfinches, etc., are distinguished by the difference of plumage by birdsellers.
VI. Tooth-Billed— *Type*: *The Robin.*—This bird, like the sparrow, is a *percher*, the legs and feet therefore are similar; and it has strong, curved, and sharp claws. The *food* is somewhat similar, too; for a part of the year it consists of worms and grubs; of berries, fruits and seeds in season; in winter, near man's abode, of food-scraps.	VI. Ask the children what bird comes to us for food in winter, but flies away in spring. (Robin.) Why cannot it get food for itself in winter? (Too cold for insects, and fruits and seeds are all gone.) Ask class what birds perch on trees; and what perching means; and what sort of toes are required for it.
(*a*) The *beak* is like the sparrow's, short and conical; but the *upper* part is notched to provide for the cracking of *seeds*: similar in canary, of the same group, whence their name, *tooth-billed.*	(*a*) What do we crack nuts with? (Nut-crackers.) What have the robin and sparrow, etc., like these? (*Beak.*) Contrast this with the swallow's shorter, softer bill; and ask the respective advantages of each.
(*b*) Nearly all our best *songsters* are in this division, as the thrush, canary, nightingale, blackbird, etc.	(*b*) Ask for names of English wild *singing* birds. What is the robin called on account of its red-breast feathers? Recite a poem on the robin, *e.g.*, "Little bird with bosom red".
(*c*) *Size and colour.*—Nearly six inches long; it has red feathers on the breast and throat; the upper part of the body is brown; and yellowish-white on the sides.	(*c*) Ask for birds of which the males have brighter plumage than the females. Why do cock-canaries, goldfinches, etc., cost more than hen-birds? (They alone sing.)
VII. Poultry— *Type*: *Fowl.*—Here again, the *feet* and *beak* are adapted to the *food* taken. All this group obtain food by scratching, hence their name of "*Scratchers*", *e.g.*, turkey, pheasant, partridge, peacock, grouse, and *domestic* poultry. The *food* is chiefly grain, seeds, and insects, or worms from the ground. The *feet* and *legs* are strong, and the *claws* like a dog's, rather than a cat's, to enable them to obtain this.	VII. Enquire from the class the characteristics of the hen's *feet, claws,* and *beak.* Get from class how these are adapted to habits. Ask for other birds of same habits and like food to fowls. Why has the fowl been *domesticated?* (For sake of eggs.) What advantage have eggs as food? (Nourishing; can be kept; take up small room; can be cooked in many ways.) Enquire where the *domesticated* pheasants, turkeys, and peafowls are kept; and where *wild* partridges and grouse are found.
(*a*) The *claws* are strong and blunt, three toes in front, and one behind raised above ground. They	(*a*) Show class the *leg* and *claws* of a hen and duck, and contrast these. The toes can be made to move in these

NOTES OF LESSONS—ORDERS OF BIRDS—*Continued.*

Matter.	Method.
are strong, to bear the weight of the bird when roosting on a perch. (*b*) The *beak* is not always strong enough to break up food, so there is a *gizzard*, which acts instead of teeth. This has hard ridges, and strong muscles. To aid this, small stones are swallowed to rub against the grain. (*c*) *Wings.* These are short for the size and weight of the bird, since they are not used for flight, except to escape from foes. The male is larger than female, with more beautiful plumage, strong "*spurs*" on the lower part of the leg for offence, and fleshy "*wattles*" on the head, and under the bill. The male crows, the hen clucks and cackles.	specimens by pulling the "guides" or tendons. (*b*) If possible, show a fowl's *gizzard*, and open it. Call attention to hens picking up gravel from the roadside; and to people giving this to fowls cooped up in a fowl-house, to help them to bruise their hard food (barley and other tough grains). (*c*) Ask why fowls have not strong *wings*: and why they cannot fly like grouse, etc. (They have not used their wings: they have been for a very long time domesticated.) Wild birds when domesticated lose their wild habits: and in doing so they also lose the full use of those parts of their bodies (wings, etc., in birds) which have not been employed for a long time.
VIII. Pigeon— This belongs to the same Order as the preceding, but has the following points of difference from it:— (1) *The beak* has a bold *prominence* at the base. (2) *The wings* are adapted for rapid and long flight in a wild and a domesticated state. (3) They live in *pairs* for life. This is useful for mutual aid in building nests, foraging for young, hatching eggs, and defending nests. (4) They lay *two* eggs only for each brood, whereas the hen lays a great number. (5) The young are fed in the nest on *soft food*, ejected from the crop of the parent bird; whereas chickens at once forage for themselves. (6) The *male* aids the female in sitting on the eggs. (7) Wild pigeons build in *trees*. (8) In drinking they *dip* their bills in water, and keep them there until thirst is quenched. The *colours* of pigeons vary: black, white, grey, etc., according to very many varieties.	VIII. Show both a live and a dead pigeon to the class, and get from these the various points of difference enumerated below. (1) Point out these *excrescences* in a picture. (2) What use do we make of the strong flight of the pigeon? (It carries messages.) (3) Tell class that many birds "*pair*" only for the season; others not at all. Ask children what birds can do better with two at a task than one: and ask also for some other pairing birds. (4) Ask for number of eggs laid by other common birds (lark, sparrow, etc.). (5) Tell class that this habit gives rise to the name of "pigeon's milk", and that the food having been thus partly digested in the parent bird's crop, forms a kind of "*milk*". (6) Refer to opposite habit with *fowls*. (7) Enquire where *domestic* pigeons nest. (8) Ask what is the mode of drinking of most other birds. (They put beaks in water, then *jerk* it down their throats.) Ask the class what different *colours* they have seen in pigeons; and show these in pictures, in black and white, and in coloured illustrations.

93. NOTES OF LESSONS—BIRDS.

(THIRD SKETCH AND RECAPITULATION.)

Matter.	Method.
I. Classification— Birds belong to the backboned animals, or *Vertebrates*, but differ from the *Mammals* in the following respects:—	I. Refer back to the two great subdivisions of the Animal World: the *Backboned* and *Not-backboned*: or the *Vertebrates* and the *Invertebrates*. Ask for the general characteristics of *Mammals*, out of the former. Now contrast any well-known *bird*, with a cat, dog, horse, or cow, in respect to the latter's:—
(*a*) *In laying eggs*, and hatching young.	(*a*) Reproduction (laying eggs).
(*b*) *In not suckling their young.*	(*b*) Feeding its young (by carrying food to it).
(*c*) The covering is of feathers, not hair. Feathers, though made of the same materials as hair and fur of mammals, differ in construction from these.	(*c*) Covering (feathers).
(*d*) They mostly *fly*, and few mammals do so.	(*d*) Means of locomotion (flying).
(*e*) The skeleton, as in the mammals, is internal, and bony, but *lighter*.	(*e*) Character of skeleton (light).
(*f*) Breathing is by the lungs, but the *hollow bones* assist.	(*f*) Respiration (lungs and air cells).
(*g*) The *heart* has four chambers, but the blood is *purer* than in mammals.	(*g*) Heart and blood (heart four-chambered, blood pure).
II. Bones— These are *lighter* than those in mammals, and hollow, with air inside instead of marrow, to give lightness and strength. They are also very *strong*, for the attachment of, and resistance to, powerful muscles; yet they are not heavy enough to impede flight.	II. Enquire which weighs more, a bird or a mammal of the same size, *e.g.*, a cat, and a fowl. What causes this difference? Is it in the flesh, or in the *bones*? (Bones.) Show the class a hollow bone of a portion of a cooked fowl, with strong tendons still on it.
III. Respiration— The bones in birds are connected with *air-vessels* leading to lungs, for breathing, which can be effected even through broken bones, with head under water. The chest has air-cells; others are in the back, and between the ribs. The lungs pump *reserve air* into these receptacles. Without this air, a bird could not *sing* long	III. Refer to a child's balloon, which, being inflated with air, is readily made to rise. Birds, on account of their air-vessels are in like manner light-bodied, and rise easily. Show a pair of *bellows*, and draw on the blackboard alongside of it a sketch of human lungs and windpipe. Also illustrate lung-action by means of a child's "squeaker" or toy balloon.

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
nor loudly. The chest is like a pair of *bellows*: the front and back like boards, the throat like the pipe or nozzle.	Illustrate the bird's respiration by comparison with our own. Tell class that sometimes a canary does not weigh much more than a shilling piece, owing to its air cells and hollow bones.
IV. Limbs and Skeleton— (*a*) Birds' *fore-limbs* are not much used for locomotion on the *ground*, or prehension; but to sustain and impel the body in the *air*. They are *long* to turn quickly in insect-eaters, as in swallows; *light* and *strong* to sustain prey in birds of prey, as eagle, hawk, etc. Birds, which *run* rather than fly, as the ostrich, have *short wings* and *long strong legs*. The bird's upper and lower arm-bones are very much lengthened; the wrist bones small and few (two); these correspond to our palms, and are united together. Birds have little to correspond with our fingers. The big bones are planned as in mammals, *viz.*: two thigh bones, and two leg bones, with a long bone in the place of the ankle and foot bone, the length according to the bird's height.	IV. (*a*) Enquire as to the use of the *fore-limbs* of the mammals already taken; and compare with the use of ours, and of a bird's. Ask the class to contrast with respect to *wings*, the swallow, eagle, and ostrich, and show how each of these has the wings modified to suit its habits and needs. Tell children how the ostrich is hunted with the swiftest horses, and the use of the wings to the bird in flight. Draw a diagram of the skeleton of a bird's *wing*; and point out on it the parts enumerated in the "Matter" column. Further illustrate these if possible, by the actual skeleton of a bird's wing. Do the same with the skeleton of a bird's *leg* to show the thigh bones, the leg bones, and the bones succeeding these.
(*b*) *The toes* vary in number, arrangement, and number of the joints. They are generally four, three in front and one behind.	(*b*) Contrast the use of these in Scratchers, Perchers, Swimmers, and Waders, showing how each is provided with what best suits its needs.
(*c*) *The ribs*, for economy of space, are not hollow; they are locked together by long projections.	(*c*) Enquire how our ribs are mostly jointed to each other on the *backbone* behind, and the *breastbone* in front.
(*d*) *The neck*. The number of *neck* bones in birds varies from nine to twenty-three (not seven, as in mammals).	(*d*) Get from the class the use to birds of an *elongated* neck; compare with giraffe, and illustrate by ostrich, swan, etc.
(*e*) *The jaws* of birds have no *teeth*, nor *lips*; they are covered with a horny substance like our nails.	(*e*) Get from the class why birds require neither *teeth* nor *lips*. (They swallow their food whole, and divide it in the *gizzard*.)
(*f*) *The beak* greatly determines the classification of birds. In those that *tear* food it is strong, sharp and curved, as in *birds of prey* (eagle).	(*f*) Make drawings of the different kinds of *beaks* of birds. Ask class for illustrations of each: and get from them as much as possible the *use* of the various modifications.

93. NOTES OF LESSONS—BIRDS.

(THIRD SKETCH AND RECAPITULATION.)

Matter.	Method.
I. Classification— Birds belong to the backboned animals, or *Vertebrates*, but differ from the *Mammals* in the following respects:—	I. Refer back to the two great subdivisions of the Animal World: the *Backboned* and *Not-backboned*: or the *Vertebrates* and the *Invertebrates*. Ask for the general characteristics of *Mammals*, out of the former. Now contrast any well-known *bird*, with a cat, dog, horse, or cow, in respect to the latter's:—
(*a*) *In laying eggs*, and hatching young.	(*a*) Reproduction (laying eggs).
(*b*) *In not suckling their young.*	(*b*) Feeding its young (by carrying food to it).
(*c*) The covering is of feathers, not hair. Feathers, though made of the same materials as hair and fur of mammals, differ in construction from these.	(*c*) Covering (feathers).
(*d*) They mostly *fly*, and few mammals do so.	(*d*) Means of locomotion (flying).
(*e*) The skeleton, as in the mammals, is internal, and bony, but *lighter*.	(*e*) Character of skeleton (light).
(*f*) Breathing is by the lungs, but the *hollow bones* assist.	(*f*) Respiration (lungs and air cells).
(*g*) The *heart* has four chambers, but the blood is *purer* than in mammals.	(*g*) Heart and blood (heart four-chambered, blood pure).
II. Bones— These are *lighter* than those in mammals, and hollow, with air inside instead of marrow, to give lightness and strength. They are also very *strong*, for the attachment of, and resistance to, powerful muscles; yet they are not heavy enough to impede flight.	II. Enquire which weighs more, a bird or a mammal of the same size, *e.g.*, a cat, and a fowl. What causes this difference? Is it in the flesh, or in the *bones*? (Bones.) Show the class a hollow bone of a portion of a cooked fowl, with strong tendons still on it.
III. Respiration— The bones in birds are connected with *air-vessels* leading to lungs, for breathing, which can be effected even through broken bones, with head under water. The chest has air-cells; others are in the back, and between the ribs. The lungs pump *reserve air* into these receptacles. Without this air, a bird could not *sing* long	III. Refer to a child's balloon, which, being inflated with air, is readily made to rise. Birds, on account of their air-vessels are in like manner light-bodied, and rise easily. Show a pair of *bellows*, and draw on the blackboard alongside of it a sketch of human lungs and windpipe. Also illustrate lung-action by means of a child's "squeaker" or toy balloon.

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
nor loudly. The chest is like a pair of *bellows*: the front and back like boards, the throat like the pipe or nozzle.	Illustrate the bird's respiration by comparison with our own. Tell class that sometimes a canary does not weigh much more than a shilling piece, owing to its air cells and hollow bones.
IV. Limbs and Skeleton— (*a*) Birds' *fore-limbs* are not much used for locomotion on the *ground*, or prehension; but to sustain and impel the body in the *air*. They are *long* to turn quickly in insect-eaters, as in swallows; *light* and *strong* to sustain prey in birds of prey, as eagle, hawk, etc. Birds, which *run* rather than fly, as the ostrich, have *short wings* and *long strong legs*. The bird's upper and lower arm-bones are very much lengthened; the wrist bones small and few (two); these correspond to our palms, and are united together. Birds have little to correspond with our fingers. The big bones are planned as in mammals, *viz.*: two thigh bones, and two leg bones, with a long bone in the place of the ankle and foot bone, the length according to the bird's height.	IV. (*a*) Enquire as to the use of the *fore-limbs* of the mammals already taken; and compare with the use of ours, and of a bird's. Ask the class to contrast with respect to *wings*, the swallow, eagle, and ostrich, and show how each of these has the wings modified to suit its habits and needs. Tell children how the ostrich is hunted with the swiftest horses, and the use of the wings to the bird in flight. Draw a diagram of the skeleton of a bird's *wing*; and point out on it the parts enumerated in the "Matter" column. Further illustrate these if possible, by the actual skeleton of a bird's wing. Do the same with the skeleton of a bird's *leg* to show the thigh bones, the leg bones, and the bones succeeding these.
(*b*) *The toes* vary in number, arrangement, and number of the joints. They are generally four, three in front and one behind.	(*b*) Contrast the use of these in Scratchers, Perchers, Swimmers, and Waders, showing how each is provided with what best suits its needs.
(*c*) *The ribs*, for economy of space, are not hollow; they are locked together by long projections.	(*c*) Enquire how our ribs are mostly jointed to each other on the *backbone* behind, and the *breastbone* in front.
(*d*) *The neck.*—The number of *neck* bones in birds varies from nine to twenty-three (not seven, as in mammals).	(*d*) Get from the class the use to birds of an *elongated* neck; compare with giraffe, and illustrate by ostrich, swan, etc.
(*e*) *The jaws* of birds have no *teeth*, nor *lips*; they are covered with a horny substance like our nails.	(*e*) Get from the class why birds require neither *teeth* nor *lips*. (They swallow their food whole, and divide it in the *gizzard*.)
(*f*) *The beak* greatly determines the classification of birds. In those that *tear* food it is strong, sharp and curved, as in *birds of prey* (eagle).	(*f*) Make drawings of the different kinds of *beaks* of birds. Ask class for illustrations of each: and get from them as much as possible the *use* of the various modifications.

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
Those living on *hard seeds* have straight, hard, beaks, as in *Scratchers* (poultry). The parrots, etc., feeding on *nuts*, have hard *curved* beaks, the upper half pointed and bending over the short, lower half. Some beaks are *notched* near the end of the upper half, which is slightly turned downwards, as in the canary. The young canary feeds on soft food; but the adult chiefly on seeds split by this notched beak.	Associate together the *beaks* and *feet*; and show drawings of beaks side by side with the feet and claws of the same orders. Particularly show how the beaks and talons of birds of prey are both *curved* and *strong*: and enquire the reason of this. Remind class that birds of prey and beasts of prey, being both flesh-eaters (carnivorous), will require similar instruments to take and retain their heavy and struggling prey.
V. The Covering— *The Covering* is of *feathers*, which are bad conductors, and retain much air among them; this air is also a bad conductor, so the body-heat is retained by the feathers. The wing-feathers are:— (*a*) "*Primaries*", attached to what corresponds with our hand; (*b*) "*Secondaries*", on part corresponding with our fore-arm; (*c*) "*Tertiaries*", on part corresponding with our upper arm. (*d*) "*Coverts*" *cover* the quill part of the feathers, which would otherwise be bare.	V. Enquire as to suitability of feathers for covering to birds (*light, warm, strong*), and refer to the use of feathers employed in dress, and feather trimmings. Compare with fur. (*a*) Show on a fowl's wing the *kinds* of feathers there are. Tell class that "primary" means first and most important. (*b*) Tell class that "secondary" means second rate in importance. (*c*) Tell children that "tertiary" means only third rate in importance. (*d*) Remind class that an outside coat is called a "*covert*" coat, because it *covers*.
VI. Feeding— Birds eat often, and the food, by the aid of air taken in breathing, gives out much heat; which is retained by the feathers. (*a*) *Drinking.*—Except pigeons, birds generally take up water with the beak; this, when the head is raised, runs down the throat. (*b*) *The Tongue* varies much; sometimes it is covered with a *horny* substance, when it is of no use as an organ of *taste*. Birds of prey have *soft*, fleshy, broad tongues; the woodpecker's is *long* and thin, to collect insects; the duck's very *sensitive*, to select its food out of the mud.	VI. Remind children that *fuel* is used to give heat in a fire: tell them that *food* is the fuel of the body; and that we feel warmer after a full meal than when very hungry, and especially after *fatty* food. (*a*) Enquire how the canary in the cage takes its water. Ask why it would not do for birds to take much water at a time. (It would make them heavy.) (*b*) Draw a diagram of a woodpecker's forked tongue. Refer to the bill of the bird used as a boring instrument in the rotten bark of trees. Ask class what they have seen ducks do in the water when feeding with their bills. (Filter mud to extract food.)

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
VII. Sleeping and Perching— When the bird's leg is bent, the toes are drawn in. *Perching* makes the toes clasp the perch; so the bird cannot fall till it stands up. Most birds sleep while perching on a branch. A ribbon-like cord passes from the thigh *over* the knee, thence to the back of the leg (kept there by a muscular ring), and so down behind the leg bone to the toes; it then divides into cords under the toes.	VII. Make a drawing of a bird's toes extended in *walking*, and contracted in *perching*. Illustrate by the open and drawn fingers. Refer to a *sloth* sleeping suspended on branches, body downwards; and to a *bat* hanging by the hooks on its wings. Illustrate these muscular involuntary contractions by a child sleeping with its fingers clasped over an object, without any will or intention (involuntary muscular action), on the part of the child.
VIII. Flying— When the *wing* beats down on the air hard and suddenly, the bird rises. The wing is *arched*, the hollow side downwards, like an umbrella; hence the air is more strongly pressed in the down, than in the return upper stroke. The wing acts as an *oar*. The quills are set like bars of a Venetian blind. In the upstroke they are set so that the air passes between them; but in the downstroke they form an unbroken surface.	VIII. Illustrate by an *umbrella* thrust up, and pulled down (but this has an unbroken surface for *both* strokes, without spaces, as in the bird's feathers). Further illustrate by means of a *fan* made of separate ivory or wooden slats, and closed and opened in the down and up strokes. Compare with "feathering" an *oar* in rowing. Show that when *resistance* is needed the *surface* is enlarged; when not, it is diminished.
IX. Summary of Orders— (1) Birds of prey:—hawk. (2) Cloven-jawed:—swallow. (3) Tooth-billed:—robin. (4) Cone-billed:—sparrow, rook. (5) Poultry tribe:—pigeon. (6) Web-footed:—swan, duck. (1) *Birds of Prey—The Hawk.*—This has hooked *beak* and *claws*. As in beasts of prey, the claws are sharp, strong, curved, and used for seizing prey. When the leg is bent the toes are drawn in, to strike and *kill* prey easily; the weight of the bird, and its impulse, driving the claws into the prey. The *beak* is used for tearing and eating. It curves downward with a sharp hook. There are three toes in front, and one behind.	IX. Ally these Orders with the more popular division into Scratchers, Waders, Swimmers, Runners, etc. (1) Refer to the characteristics of *beasts* of prey. Show similarity of these to *birds* of prey, in *beak* and claws, compared with *teeth* and claws. Ask class for instances of this group, and for their prey, in this and other countries. Illustrate the order by reference to the *eagle*, as a type of those feeding on *living* prey. Do the same with the *vulture*, as typical of those feeding on dead prey (carrion). In the country, ask the children what they have seen hawks do at sight of other birds. (Hover, and pounce down on them.)

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
	Whilst calling attention to the provision made by nature *for* birds (and beasts) of prey, remind children that the "prey" is also provided with means of escape, in flight, colour, refuge in coverts, etc.
(2) *Cloven-jawed—The Swallow.*—This is so called from the beak and mouth opening wide (in some behind the eyes), for catching insects *on the wing.* The swallow has small weak legs, seldom perching, and being mostly on the wing; the toes point forwards. The male has brighter plumage than the female; glossy blue on back, the breast buff white. It is about the same size as a robin and canary. The swallow "twitters".	(2) Enquire from the class what are the chief *habits* and *characteristics* of swallows: their *food, abode, flight,* mode of *building* nest, *colour*; time of arrival and departure to and from this country, and why they *migrate.* Enquire what other birds quit us in the autumn, and why migrating birds do so; and why four-footed animals cannot do so in England.
(3) *Cone-billed—Sparrow, Rook.*—These have short, thick, conical bills; the rook, *to dig up* insects. It also feeds on grain. The *sparrow* eats caterpillars and soft fruits, and is useful for destroying flies. Both are *perchers*; the feet are open, not webbed. The rook is shiny black. The sparrow (male), head and neck, greyish; chin and throat, deep black; back, brown; wings, brownish-black with white bar. Female, dull brown; bar on wing not so prominent. The *rook* caws; the *sparrow* chirps.	(3) Do the same as above with the cone-billed birds in general. Compare these with each of the other types. Ask the children what they can say about the *habits* of the rook and sparrow; their *colour,* mode of taking *food,* etc. In the country a *preserved* (stuffed) sparrow and rook should be kept for illustrating this lesson. The skins of these can be bought from the Natural History (taxidermist's) shop in the town; or the children will bring them to the school for this purpose.
(4) *Tooth-billed—Robin, Thrush, Canary.*—These have upper beak notched near the point, hence their name. They are all *perchers,* with three toes in front and one behind; toes open; and the males are good songsters. The robin and thrush feed on insects, worms, berries, tender fruits, and seeds. The latter eats snails, breaking the shells by throwing them against a stone. It also feeds for a month or two on grain and insects. The thrush is russet brown, with speckled breast; the robin brown, with red breast. The thrush is the larger of the three.	(4) Do the same with robin, thrush, and canary. Compare these with each of the other types. In the country show fragments of snail shells broken by the thrush in spring time, when finding food for its young. Tell the class that the thrush often goes to the *same* stone for this purpose; and refer to the heap of broken shells found at these spots: and ask the class to look out for such. This is the slaughter-house of the thrush. Show these birds alive and preserved to the children: and get from the latter the points indicated in "Matter" column.
(5) *The Poultry Tribe—Fowl, Pigeon.*—Being grain feeders these	(5) Show the class a fowl's gizzard. Explain *why* these birds get the name of

NOTES OF LESSONS—BIRDS—*Continued.*

Matter.	Method.
have a *gizzard*. The fowl is a *Scratcher*, the claws being well adapted for this, and growing fast; and the legs strong. The male is larger and better plumaged than the female. The *colour* is various, as in "Leghorn", "Minorca", "Game", etc. Note the fully developed *spurs* on the latter, and the colour of the comb. The cock crows; hens cackle; pigeons coo.	"*Scratchers*"; and point out the suitability of their beaks and claws to their habits. Get from class as many differences as possible between fowls and pigeons, illustrated by reference to a dead pigeon shown to the class. Ask children for the names of some varieties of poultry, and of pigeons.
(6) *Web-footed—Duck, Swan.*—The feet are adapted for *swimming*. When drawn forward the toes close, and the webs fold, to offer the least resistance; with the back stroke, the toes open out. The duck's *beak* is flattened; the edges have a double row of ridges. The lower *jaw* has its edges turned up in a fold, outside of which the comb-like teeth of the upper jaw fit. This serves as a *filter*, the tongue selecting food by feeling alone. The male duck's plumage is finer than the female's.	(6) Show the class a web-foot cut off from a duck. Show also its beak, and point out to class the suitability of both to the needs and modes of life of the owners. Show children a few of the bright feathers of the drake. Ask class for any items of information they can furnish as to the shape, size, appearance, colour, mode of progression, place of abode, and habits of the swan, duck, and goose. Enquire in what respects these three types agree with, and in what they differ from, each other; and why so in the latter instance.

94. BIRDS—SUMMARY.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Birds**, are **warm-blooded** like Mammals, and so **differ** from Reptiles and Fishes. The young are **hatched from eggs**, and in this are unlike Mammals, but like Reptiles and Fishes. They are covered with **feathers**, not with hair (wool or fur), as in Mammals; nor with horny plates as in Reptiles, nor with scales as in Fishes.

II. **The Orders** include :—

(1) **Birds of Prey**, as the eagle, hawk, owl, etc.

(2) **Perchers**, as the sparrow, crow, and most song-birds.

(3) **Climbers**, as the cuckoo, parrot, wood-pecker, etc.

(4) **Runners**, as the ostrich.

(5) **Waders**, with long legs and necks, as the stork.

(6) **Swimmers**, with webbed-feet, as duck, goose, swan, etc.

Modes of Progression.

(7) **Scratchers**, as poultry.

It will be seen that this **popular** kind of division of Birds, depends on :—

(*a*) The **kind of food** eaten : **Birds of Prey** (1).

(*b*) The **Mode of Obtaining** it ; as **Scratchers** (7).

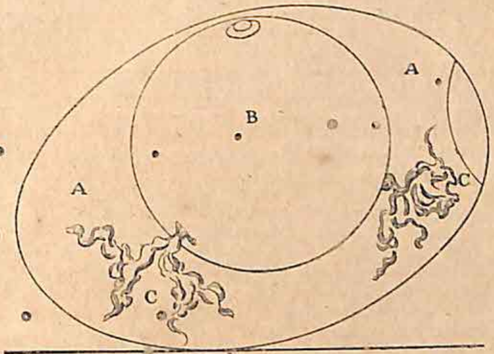
(*c*) The **Modes of Progression** ; **Climbers, Runners, Waders, and Swimmers** (3)-(6).

(*d*) The **Modes of Resting** ; **Perchers** (2).

95. NOTES OF LESSONS—EGGS.

(First Sketch.)

Matter.	Method.
I. Introduction— All birds lay *eggs*. These eggs differ in appearance, but all alike consist of *white* and *yolk* inside. Besides Birds, most Reptiles and Fishes, and many other animals still lower down in the scale of life, lay eggs, such as the *soft-bodied* (Mollusca), and the *jointed* animals (Articulata).	I. Show class some hen's *eggs*, one raw, and one boiled ; and one boiled hard, and one soft. Also show any other eggs readily obtained, such as those of the sparrow, lark, brown and green linnet, etc. Pull to pieces before the class the cooked hard-roe of the herring, to show the separate eggs in it ; do the same with the raw eggs of snail and crab.
II. Shape— Most eggs of birds are nearly *semi-spherical* at one end, and more pointed at the other. Any *angular* shape would be inconvenient to the bird to sit upon when hatching. In doing this the egg is frequently *turned*, and the rounded shape allows of this. Although easily rolled by the bird in the nest, yet it will not roll in a *straight line*, like a ball on a flat smooth surface. This rounded shape is also well suited for *packing* in the nest, with the pointed ends inwards. Where birds lay *many* eggs this shape is of great advantage, since eggs must be packed in a small space for all to be kept covered and warm. *Sea* birds build their rude nests in bare rocky situations. The shape of the egg then prevents it from being *rolled away* from the nest by rough winds.	II. Show class that each end of the egg is *arch-shaped* ; and point out that pressure, up to a limit, only strengthens an arch. The egg is a *double* arch, one half resting on the other, as is sometimes seen in arched foundations of houses, roadways, etc. Let the teacher roll a hen's egg across a flat table, to show that it will not roll in a *straight* line. The teacher should point out that the circumference increases as the diameter increases ; therefore the circumference of the large circle at the larger ends of the eggs, is greater than that at the smaller ends. Ask the class *why* the eggs must be kept *warm*. (The birds inside are *alive*, and require warmth.) Show a picture in a reading book of the situations of a *sea bird's* eggs on a rocky ledge, overhanging the sea.



Structure of an Egg—AA, White or Glaize ; B, Yolk.

NOTES OF LESSONS—EGGS—*Continued.*

Matter.	Method.
III. Parts of Egg—	
(*a*) *Shell*: of many *colours*, variously *marked*; no two birds have their eggs coloured alike. The hen's is generally nearly white. The shell is generally thin, smooth, hard, brittle, and *porous*. The porous nature of the shell is important, as the chicken lives inside, and requires *air* from outside. The *keeping* of eggs depends on the proper stopping up of these pores, by packing in salt or lime, smearing with grease, etc. The egg has *moisture* in it which evaporates, so eggs become *lighter* by keeping: and thus stale eggs float in water. Underneath the shell, and closely sticking to it, is an inner lining.	III. (*a*) Show by specimens that the *same species* of birds have eggs coloured alike. A Cochin China fowl's eggs are darker than most other fowls' eggs. Point out that if the shell were *too hard*, the tender beak of the chicken inside would not be able to break it, and the animal to come out. Explain how the *lime* and *salt* being in a powder, would exclude the air; and that the *grease* would stop up the pores of the shell, as varnish would do those of our skin. Illustrate the floating of eggs that have been kept, by reference to a wet sponge drying in the open air, and then floating for a while on the top of the water; whereas a saturated sponge will sink at once.
(*b*) *Skin*, or *Membrane*.—This is white, thin, tough, and semi-transparent. Prick the broad end of the raw egg, and nothing comes out. Cut open the hard boiled egg lengthwise, and the reason of this is seen. The skin here is *double*, and encloses a space full of air. It is not till the inner skin is broken or pierced, that the contents come out of the raw egg. This air-cavity is of great use to the young *chicken* inside, as	(*b*) Remove the shell from the surface of an egg, and show the class the delicate skin beneath. To show the existence of the *air-cavity* at the broad end of the egg, try to make an egg *stand* on this end, and it tumbles. Now violently shake the egg to break this inner membrane. The contents then run into this cavity, and the centre of gravity is thereby lowered. Now it is an easy task to stand the egg on its end. Columbus when asked to stand an egg on its broad end, knowing of this air-

NOTES OF LESSONS—EGGS—*Continued.*

Matter.	Method.
from it the chick can fill its *lungs*, and so swell out, and thereby thrust the shell from its body, and escape into the outer air to make a beginning of life on its own account.	space, cut through the egg with a smart blow of his sword. He then easily made the egg stand on the end without the shell at the bottom.
(*c*) *The White.*—Under the skin is a thick white substance. Prick this skin in a raw egg, and some of the contents run out. This is colourless, liquid, and sticky, and is often used in confectionery as a varnish, or glazing to give cakes a shiny surface. It becomes white and *hard* when boiled. The *albumen* in meat, fish, and eggs always "sets", or coagulates, under cooking, whether by boiling, baking, frying, or roasting.	(*c*) Tell the class that most of the egg, both white and yellow, is what is called *albumen*, and show them that this substance *sets* or "*coagulates*", with heat (185° F., or less than boiling point). This setting thus turns the semi-liquid, and semi-transparent white to a *solid*. When the egg was being formed, the white substance was laid down in "*shells*" or flakes; these thin layers are seen in a hard boiled egg.
(*d*) *The Yolk or Yelk.*—In the middle is a *yellow, oval* mass. This is the *yolk*. If an egg be carefully turned out into a vessel, this yellow yolk does not mix with the white. It is enclosed in a bag. If this bag be pricked or cut the yellow substance runs out. To the ends of the yolk-bag are attached little twisted white *cords* which prevent the yolk from turning round too quickly when the egg is rolled. They also serve as *anchors* to keep the yolk in one position. In whatever position the egg is placed, the yolk is always nearer the top side, and so nearer the bird for the warmth required in hatching.	(*d*) Show the class in position the *yolk* of a hard boiled egg by carefully removing the white outside. Show the children that it is of the same shape as the whole egg. This is the most nutritious part of the egg. Sometimes an egg has *two* yolks, or is "*double-yolked*"; then both ends of the egg are generally *broad* instead of one being elongated. Spin a ring on a string stretched between the two hands, to illustrate the movements inside the egg. Refer to the way in which a young baby is swaddled up in flannel to keep it quite warm: and to young chickens kept in flannel and in a basket before the fire.

96. NOTES OF LESSONS—EGGS.

(SECOND SKETCH.)

Matter.	Method.
I. Hatching— This requires *heat, moisture*, and *turning*.	
(*a*) *Heat.*—To obtain this the eggs are well covered, mostly by the female bird. When hatched *artificially* they are placed in a	I. (*a*) Refer to the *materials* and structure of most birds' *nests* as fitted to keep the eggs warm, whilst the parent bird is temporarily absent. These consist

NOTES OF LESSONS—EGGS—*Continued.*

Matter.	Method.
box, oven, or drawer, and supplied with artificial heat, generally from gas, which is regularly kept up. The chicken always lies on the upper side of the yolk, on a small yellow patch seen in the raw egg; this is for the chicken to get the most heat from the mother bird.	of moss, wool, etc., and the inside of the nest is often lined with mud, etc., or, as in the swallow's nest, the whole is enclosed, except for a small opening. The mother's breast at hatching time is very *hot*. She finds relief in pressing it against the colder egg. This is a reward for her patient self-denying task of hatching the eggs.
(*b*) *Turning.*—The eggs are *turned* every day by the mother, which prevents the chicken from growing *fast* to any part of the shell. When eggs hatched artificially are not turned the birds always *die* early, or are *deformed* from the body becoming fastened to some part of the shell. When the egg is turned, the yolk bag turns with it, but very slowly; and thus the chick always maintains its place on the *top*. The cords act as a *brake*, to check the yolk from turning *too fast*, that the chicken may not be hurt by rubbing against any part of the egg. The cords are *below* the centre of the yolk; and as the yolk is lighter than the white, it turns slowly and keeps the chick *uppermost*, although the yolk revolves.	(*b*) Give a brief description of the artificial hatching of hen's eggs in Egypt, etc. Draw a diagram to show the moving part, and the *cords* at the sides by which the movements are checked. Compare with a horse running round in a circle, with reins to check its movements held by a man in the centre; and revolve a weight fastened on a cord held in both hands, and turned like a skipping rope. Encourage the children to find out for themselves, or to understand when it is pointed out, how every "*adaptation of means to ends*" in nature is exactly suited to the requirements of the plant or animal showing it. Every contrivance has, as it were, been "thought out" and provided by a great *Wisdom* and an equally great *Goodness*.
II. Food— The young chick lives on the yolk and white. It is surrounded by a patch of blood-vessels. The yolk at first gets larger, and the white smaller; or the white feeds the yolk. The yolk and its blood-vessels in turn feed the growing chick. So also *our* food supplies us with blood; and our blood then feeds the various parts of our body.	II. Explain to the class that as the chicken is *alive*, it must have *food*. This it cannot get from the outside; so it gets it from the *inside*. Illustrate by the sprout of wheat, Windsor bean, etc., feeding on the rest of the seed, and turning it into the future plant. The *egg* is like the *seed* of the vegetable; the seed of the *plant* like the egg of the *animal*.
III. Breathing— We breathe, and purify our blood, by our lungs; but the chicken does not use its lungs until it is ready to leave its shell. It is wrapped in a covering or hood full of blood-vessels. These take	III. But to keep alive we must do something else besides *eat*. Ask the class what else would make us die besides having no food. (We must have *air*.) So also the chicken in the shell wants air; though it cannot yet breathe it.

NOTES OF LESSONS—EGGS—*Continued.*

Matter.	Method.
up the air through the porous shell, as the blood-vessels do the purifying work of our lungs ;—the air purifies the chick's blood. When ready to leave the shell, the chicken makes an opening in the inner skin of the air space ; it then begins for the first time to breathe the air there into its lungs. On the 21st day it pecks open the broad end of its shell, and escapes; but very weak and tired from its work of breaking out of prison.	*Fishes* in the same way get air, and yet have no lungs, but get it by means of gills. In both cases the air passes into the blood, and that is all that is required. This is really the same result as the "air" getting into our blood. Only in our case the air first passes down our throats and goes into the lungs, where the blood-vessels are that take it up. Give a word-picture of the escape of the chicken from its shell.
IV. Nests— The nest is necessary to protect and keep warm the eggs while hatching, and the young, and for their comfort afterwards. Nests, like eggs, are not all alike, but differ according to the habits of the builders. *Wading* birds have nests near the water. *Perching* birds build in trees: non-perchers in holes, etc. *Scratchers* on the ground, etc. The *materials* also differ, depending on the habits, place of abode, requirements of young, etc., hence some are lined and others not.	IV. Most children think that birds build nests as *homes*, and shelters *for themselves*. Do away with this false notion :— (1) Birds do not use their nests when *shelter* is most required, viz., in winter time. (2) The *male* bird generally perches outside of it. The purpose of the nest is rather to give a resting place to the *eggs*, and to the *young* when hatched. Having served this purpose, the nest is generally left to decay. Point out how the *materials, structure,* and *situation* of nests are suited to the builders, from as many different birds' nests as the children know, and recite "A Bird's Nest". (Hurdis.)
V. Examples— (*a*) The *Sparrow* is a *percher*, hence it builds in hedges and trees, and has a well-lined nest, since its young, when hatched, have little covering. (*b*) The *Swallow* is a *non-percher*, and hence builds in holes, under eaves ; or attaches its mud-nest to buildings. Like a good mason it strengthens the mud material by mixing it with hair, etc. (*c*) The *Hen* is a *Scratcher*, and makes a hole in the ground. Its nest is made of straw or hay, and is *not* lined, since its young are well feathered at birth. (*d*) The *Sand-martin* obtains its food from the water, and	V. (*a*)-(*f*) Briefly point out what marks are distinctive to the nests of the *Perchers, Scratchers*, etc., and show how well the names fit the habits. Keep in the school a *collection* of birds' nests : but discourage the useless and unnecessary pillaging of these by boys. Try to create in the children a spirit of *love* and *admiration* for these beautiful structures and their builders, by pointing out the marvellous *instinct* each *bird* and each species exhibits, in choosing the best *materials*, the best *situations*, and the best *modes of construction*, for the nests : and the *patience* the building of these requires. Ask the class for the items given under the heads (*a*)-(*g*) in "Matter" column : and supply where wanting.

NOTES OF LESSONS—EGGS—*Continued.*

Matter.	Method.
makes its burrows in the sand of a bank. The burrow runs upwards, and hence its nest is not flooded, and its eggs and young are safe from rains. (*e*) The *Kingfisher* uses the refuse of food, bones of fish, etc., to make its nest. (*f*) *Woodpeckers* obtain their food from insects, etc., in decayed trees. Hence their nests are in hollow trees, and are made of soft wood. (*g*) *Wild sea-birds* build strong nests of thick sticks, etc., that will bear the rough usage of storms and winds.	Get this information by showing the nests themselves of the various *examples* cited above. Show the class pictures from "Natural History" and other "Readers", of the Sand-martin (calling attention to the reason why this name is given to it), of the Kingfisher (and why so named), and the Woodpecker; and remind the children how well all *popular* names of "beasts", birds, and flowers describe them.

97. NOTES OF LESSONS—REPTILES.

(FIRST SKETCH.)

Types:—Common Snake, Viper, and Rattlesnake.

Matter.	Method.
I. Introduction— In previous lessons we took— (1) Animals which *walk*: cat, dog, horse, cow. (2) Animals which *fly* and *swim*: birds and fishes. Now we take animals which mostly *creep* and *crawl*. We can obtain as the commonest illustrations of these, the snail, worm, etc. In all previous cases there were *bones*, while the snail which crawls has none. But *some* crawling animals, such as the snake, have bones, as is shown in a snake's skeleton, or in the diagram of this. We now therefore take *bony* animals that *creep* or crawl, as we took bony animals which walk, fly, or swim. The snake is one of the former, and a type of the others, and stands for the *Reptiles*.	I. Show class a picture or a diagram of the bony *internal skeleton* of any mammal or bird. Then ask the class for any animals seen in the garden, or field, or hedge-side, that *crawl* on the ground. Enquire of the class which of these have *bones inside*; and which are soft and without any bones. Tell the children that it is the former group, or those that have bones inside, represented by the common English snake, with which we now have to deal. Point out to the class that the word "*reptile*" means *creeping*; and that the great Class of animals in this group thus gets its name from its mode of *locomotion*, or from crawling on the dry ground, though some, as crocodiles and alligators, live partly on land and partly in the water of rivers, lakes, etc.

NOTES OF LESSONS—REPTILES—*Continued.*

Matter.	Method.
II. Internal Skeleton— (*a*) *Backbone.*—From a diagram we can see that the snake's *backbone*, like ours, is made up of many parts. To each of these, except the tail part, a pair of *ribs* is joined. These may be compared with *our* ribs fastened to the upper part only of our backbone. These parts are joined together by "*ball and socket*" joints, and compare with our shoulder-joint, as seen in swinging the arms; and they contrast with our *hinge* joint of the elbow, as seen in moving the arm from the elbow joint. (*b*) *Ribs.*—We may compare the fastening of our ribs to our backbone with that of the snake. The latter can move its ribs upwards, downwards, forwards, and backwards. We can illustrate this by the upward and downward movements of our ribs when breathing; and show by the movements of our arms from the shoulder, what other movements the snake's ribs have. The ribs pass round three-fourths of the body, and the under side of the body is joined to them.	II. (*a*), (*b*) To explain the "*ball and socket*" joint, show class this in a shoulder of mutton bone, boiled clean; the *hinge* joint can be shown in a knuckle of pork bone. Make the children feel their own *ribs*, from back to front, to find out the two places at which they are fastened, before and behind, and the great *length* of their rib-bones. Then explain how much these ribs are *shortened*, and *increased in number* in the snake to serve for *feet*. Let the class note that snakes have no *limbs*, as in the animals taken before, no arms, nor legs, nor wings, as in the Mammals and Birds. Point out to the class the use of the *flexible* backbone for *swimming* (in water-snakes); and for *coiling* round and *climbing* up trees to catch birds, etc.; and for their *wave-like* motion over the surface of the ground. Show how this absence of limbs enables snakes and serpents to creep into holes, crawl through bushes, etc., in search of their prey on the ground, and to escape pursuit from their own enemies.
(*c*) *Scales.*—The snake's *scales* also move forward, and can be drawn backward. In the latter action they catch on rough surfaces of objects and the ground, so that the snake is drawn forward. The snake and serpent have thus as many "legs" as they have ribs assisted by these scales. These organs may thus be compared with the hands, legs, and wings of the previous Classes. (Mammals and Birds.) We can show that the snake cannot crawl on smooth glass, because it wants the roughened surface for these scales to act upon. The scales or plates on the back take the place of the hair, wool, and fur, and of the feathers of	(*c*) Refer to the *covering* of *Mammals* (hair, fur, wool); of *Birds* (feathers); and point out that in *Reptiles* we have either *soft skin*, or *scales*, as in the crocodile. (Fishes also have scales or *hard plates.*) Refer to the way in which slates and tiles are placed on the roof of a house; one edge *over-lapping* the other. This will explain the way in which scales in serpents (and fishes), also overlap. Ask the class how these slates or tiles could be removed. (By pulling them off downwards.) But scales are removed by scraping upwards. Explain how the free edges of the scales sticking out give a *hold* of the ground, of the trunk of a tree, etc., by comparing with a rope passed round a post. The friction enables the rope to grip it. For the same purpose horses have their shoes roughened in winter to grip the ice. Any roughened surface gives a good grip,

NOTES OF LESSONS—REPTILES—*Continued.*

Matter.	Method.
the previous Classes of animals. (Mammals and Birds.) In the lower animals without backbones (the Invertebrates) we have butterflies (insects) which also have scales, but these are of very-different nature, colour, and size. (*d*) *External Skeleton.*—This consists of the scales overlapping like the tiles or slates on a roof, the hinder edges being free. The scales on the under part of the body are larger than those on the upper. The skin and the scales on it are "cast", or thrown off, just as in the case of the crab. The *ribs* and *scales* are for *locomotion.* The free ends of the ribs are joined by muscles to the broad plates on the under surface of the body. It is by this joint action of the ribs, scales, and connecting muscles, that the snake moves forward. The ribs press the scales forward and backward.	or friction to hinder motion, in rubbing on a similar surface. (*d*) Explain the meaning of "*external*" as outside, and "*internal*" as inside. Tell the class that the *skeleton* includes the *skin*, as well as the *bones*. So some animals (Mammals, Birds, Reptiles, and Fishes) have an external and also an internal skeleton. Others, as insects (beetles, etc.), have only an external skeleton. Others again, as certain soft-bodied animals, or Mollusks (Mollusca), as whelk, snail, etc., have an outer *shell* only; and some of the latter have not even this, as in the garden slug.
III. The Mouth— This is specially suited for the *prehension* of the food of the snake; being used for the same purpose; (1) As are the cat's *teeth* and *claws.* (Mammals); (2) And *beaks* and *claws.* (Birds.) (*a*) *The Teeth.*—All snakes feed on living prey, captured by themselves. The *teeth* can neither *tear* nor *grind*; but simply *hold*, or retain, food; so the prey must be swallowed whole, as in fishes. These teeth are small, conical, and sharp, with their points turned backwards. As the *food* (toads, mice, frogs, birds, etc.) is larger round than the snake itself, the snake's mouth, throat, and body must enlarge for swallowing. (*b*) *Jaws.*—The smaller, lower jawbones are free in front; and the upper ones joined by skin; like the silk between umbrella	III. Explain that as all animals must eat *food*, they must all have organs to *hold* it, if not to *chew* it, or *suck it* up. *Teeth* generally serve the two first purposes. Refer to *tearing* teeth of cat (flesh-eater), and *grinding* teeth of horse (grain-eater). (*a*) But some animals *bolt* their food, without chewing it, as the snake does birds, etc. But if the food be *alive* it will struggle and try to escape, so teeth will be required to *hold* the prey. So these teeth need not be flat-crowned, as for grinding, but *sharp* to pierce, *conical* to be strong, and *turned backwards*, as the prey will strive to get out of the mouth in front. To explain the swelling of the throat, etc., of the snake in passing its food, squeeze a large marble down a smaller india-rubber tube. (*b*) Tell class that there are some serpents (boa constrictors), which can swallow a whole sheep, etc., though they themselves are not more than a foot in

NOTES OF LESSONS—REPTILES—*Continued.*

Matter.	Method.
ribs, or the web in the foot of swimming birds. The hinder jaw holds the food with its pointed teeth, while the other jaw takes a fresh hold on it. (*c*) The *throat* is *elastic*, allowing the food to pass down its narrow opening into the stomach. The *ribs*, with their ball and socket joints, also open *outward* to make room for a large food-mass inside, until digested, and may thus be also compared with compasses.	diameter. This is because of the way in which the jaws, throat, and stomach are made to expand. Illustrate by opening the free leg of a pair of compasses from the fixed leg. (*c*) Remind the class that some substances, such as india-rubber, etc., are elastic; that is, they will *enlarge* for a time, and afterwards *recover* their smaller size. The throat of the snake is like this. Ask class to note the expansion upwards of their own *ribs* in breathing.

98. NOTES OF LESSONS—REPTILES: SNAKES.

(SECOND SKETCH.)

Matter.	Method.
I. Kinds— *Poisonous and Non-poisonous.*—All snakes are not *poisonous*; only those which require poison to secure their food are so. (*a*) The *non-poisonous* feed on defenceless animals (frogs, etc.); but some other reptiles depend on their *strength* to obtain their prey, which they *crush* to death. (*b*) *Poisonous* snakes feed on larger animals (birds, mice, etc.), which can struggle and defend themselves. All *marine* snakes are poisonous; and *fresh-water* ones, non-poisonous.	I. (*a*), (*b*) Explain to class that every animal has its own *defence* against others, and its own weapons of *offence*, and specially to catch living prey, if it is a flesh-eater. The animal is built up on purpose to take its *food*; as without food it could not exist at all. Some depend on *strength*, others on *craft* or *cunning*, to obtain it. Even *poison* from fangs, as in snakes (or from stings as in insects), is used for this and other purposes. These poisoners are like wild savage tribes that fight with poisoned arrows.
(*c*) The *poison.*—Like our saliva, the poison is made in small vessels *under the tongue*, and in the *sides of the mouth.* It is then *stored* up in a large *bag*, which has a *pipe* connected with the "pump"; or the "poison-tank" on each side of the head has a pipe which enters the fangs. (*d*) The *fangs* are in the upper jaw. The poison is forced into a wound by the pressing back of the fang on the tank. All venomous or poisonous snakes must have	(*c*), (*d*) Explain to the class that we make in our bodies certain *juices* (secretions), for certain purposes, such as tears, bile, and saliva, or spittle, etc. These are made out of the food we eat. So *poisonous* snakes also make a *poisonous juice* out of their food. Explain to the children that this poison, which kills the prey, does no harm to the snake itself, when it is taken into its *own* body with its food. Tell the class that many more people die in India from bites of poisonous serpents than are killed by tigers.

NOTES OF LESSONS—REPTILES: SNAKES—*Continued.*

Matter.	Method.
broad heads, to give room for the poison-vessels. When the fangs are torn out by the struggling prey, others take their place; these have been already growing one behind the other. The snake's poison may be *swallowed* without harm. To do harm, it must get into our blood *directly*, as in the case of wounding by poisoned arrows used by savages.	Draw on blackboard diagrams of the *fangs* and *poison-reservoirs* in a poisonous snake's head; and compare the act of poisoning by snake-bite with the stinging of a bee or wasp. Tell children some story of escape from death after swallowing snake-poison; as that of Queen Eleanor and her husband, Edward, wounded by an assassin.
II. Types— (*a*) *Common Snake.*—This is sometimes called the "*grass*" or "*ring*" snake, and is found in hedgerows, and grass, and in ponds, according to its *food* (toads, frogs, etc.). It is quite harmless, and can be tamed, and is non-poisonous. It gives out a very unpleasant smell when attacked, or roughly handled when tamed. *Colour.*—Greyish olive above, and greenish beneath; with spots on the back and sides, black in colour, and set in lines. The *body* is long, round like a ruler, tapering towards the tail. It bends easily, moves swiftly on land and in water without legs or fins, and climbs trees, or darts from branch to branch, without claws or hands. The *skin* is shed four times a year at irregular intervals, depending on the heat of the weather. Some snakes go to sleep in the winter, and in cold weather, especially pond-snakes. (*b*) *Viper.*—This is 18" to 20" long. A few only are found in uncultivated places, such as wild rabbit warrens, old quarries, etc. *Head.*—This has two uneven black lines meeting in the front like the letter V. The head must differ in breadth from common snake-fashion, since the viper is poisonous. The *back* is marked by a row of square black patches, placed corner to corner, or zig-zag fashion. The *food* consists of mice and birds found with it on dry heaths.	II. (*a*) In the country, the teacher should get a boy in the class to bring during the year a specimen of the *common snake*, to be kept in a box with a glass lid. This is easily tamed, and kept as a pet. From this live specimen the class should for themselves pick out the points of *colour*, etc., named in the "Matter" column. The *rounded* shape of the body may be pointed out as suitable for the snake's gliding over the ground, and in the grass, among bushes and under stones. The *casting of the slough* may be illustrated by reference to the *moulting* of a caterpillar, the *casting of the shell* of the crab, etc. Explain the winter sleep by reference to the *dormouse*, etc.; the *cold* sends the creatures to *sleep*, at a time when there is no *food* to be had. (*b*) Explain that as the *Viper* is poisonous and very dangerous, it has been nearly got rid of altogether in this country. Remind the class that England is a very favoured country with respect to noisome beasts of all kinds, especially with regard to poisonous snakes, scorpions, etc.

Head and Tail of Common Viper.

NOTES OF LESSONS—REPTILES: SNAKES—*Continued.*

Matter.	Method.
(c) *Rattlesnake.*—This is very large, and is not found in England, but *only* in America. It is so called on account of the sound produced by the "*rattle*" at the end of its tail. This is made up of many horny cups, fitting loosely into each other. When shaken these rattle like the blowing off of steam in a railway engine. The rattle must be dry to do this.	(c) Tell the class that this "*rattle*" fortunately gives intruders notice of their danger, though one may sometimes tread on the creature before knowing of its existence. Point out that each different country has its own wild animals, and even its own *kinds* of each of these. Some of these means of defence are noises, smells, fierce looks, etc., which warn the enemy not to approach.
III. Common Reptilian Characteristics—	III. Write down on the blackboard a *statement*, or *summary*, of these "*common characteristics*" to serve for recapitulation under the following heads:—
(a) Reptiles have a bony inside *skeleton*, and *horny* outside plates or *scales*, covered with a thin skin, which is often shed.	(a) *Skeleton*: bony (*internal*); horny plates, or scales (*external*).
(b) They have *lungs* like the Mammals and Birds.	(b) *Lungs* (not *gills* as in fishes); for breathing in the air.
(c) They also have a *heart* with three divisions or chambers inside it (not four).	(c) *Three-chambered heart* (not *four*-chambered, as in Mammals, and Birds; nor *two*-chambered, as in fishes).
(d) The young are produced from *eggs* like Birds, etc.; but unlike Mammals. They include crocodiles, tortoises, turtles, lizards, snakes, etc. Some live on *land*, some in *water*, this depending on the *food*. Thus land-tortoises live on vegetables and fruits; whilst water-tortoises live on frogs and fishes.	(d) They *lay eggs*; as do fishes, and some soft-bodied animals (snails, etc.), and jointed animals (crabs, etc.). Point out the difference in covering between the hard, strong, bony plates of tortoises, turtles, and crocodiles, compared with the soft skin and scales of snakes.
(e) The crocodile and alligator live chiefly in water, or in mud when the river is low; and they lay their eggs in sand. These latter have horny plates and four legs. The lizard has horny scales fastened together like house tiles. Some lizards have four legs, others, like snakes, have none.	(e) Show *pictures* of crocodile, tortoise, or turtle; and show a newt, a snake, etc. From books in the school show pictures of a *lizard*, and call attention to the number of its legs, and compare in this respect with *dry newts* and *water newts*. Keep both the latter in school brought by children from old walls and ponds.

SUMMARY.

SPECIAL INFORMATION FOR THE TEACHER.

Reptiles are **cold-blooded**; hatched from **eggs**; sometimes covered with **scales**, or horny, or bony **plates**. They breathe by **lungs** (except the **Amphibia** closely allied to Reptiles, which have both gills and lungs at the same time or in succession).

They are grouped into :—

(1) The **Snakes**, as the viper, serpent, etc.

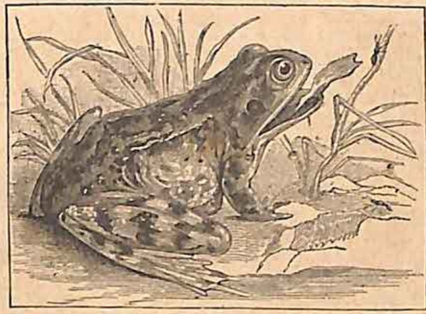
(2) The **Lizard Tribe**, as the lizard, crocodile, and alligator.

(3) The **Tortoise Tribe**, as the tortoise and turtle.

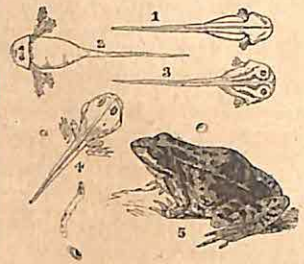
AMPHIBIA.

99. NOTES OF LESSONS—THE FROG.

Matter.	Method
I. Frog Spawn— In spring time we find in ponds and parts of streams and rivers where the current is slow, large lumps of *jelly-like* substance. These are clusters of *frog-spawn*, or eggs of frogs stuck together by a jelly substance, and each marked by a black *spot* or *speck* in the centre. These are like bunches of *grapes*, each egg being like a single berry. From each of these when hatched a *tadpole*, or young frog, may come. The *jelly* protects the eggs from being eaten by fishes, etc., and gives room for the eggs in the middle of the mass to grow.	I. This lesson should be begun in *spring*, and finished, or repeated, at a later stage. Ask the children to bring some *frog-spawn* to demonstrate with before the class; and at a later stage the teacher should show a full-grown frog as well. Try by showing the wonderful *adaptation of means to end* in the frog, and the marvellous *changes* it undergoes, to destroy that disgust for frogs which is so traditional. The spawn should be kept in a glass pickle bottle, or jar, and allowed to develop in the school, the attention of the class being frequently called to its progress.
II. Hatching— These eggs of the frog hatch in the *warm* water, when the spring advances. At first, the creatures coming out look as if they were nearly all *head*, there being little more than a very small, thin, and transparent *tail*. Children call these baby frogs or young *tadpoles*, "bull-heads", from their large heads. The word "*tadpole*" means a	II. Refer to the necessity of *warmth* in the hatching of eggs of *birds*; as of the *sun* on the hot sand in the case of the ostrich, and of the *mother* in most other birds. Call attention to the spring as the season of vegetable *growth* and of *animal birth*, the latter depending on the former for *food*, as in lambs, and most birds being born at that time. Let children note the *transparency* of the tadpole's tail; and tell them we can,



Tongue of Frog extended to secure its Prey.



Frog and its Metamorphoses.

NOTES OF LESSONS—THE FROG—*Continued.*

Matter.	Method.
"*tailed poll*", or a poll (that is a head) with a tail to it. After a time the tail disappears from sight.	under the microscope, see the *blood* in it coursing through the *blood-vessels.*
III. Development of Tadpole— Looking closer at our tadpole, we soon see on each side of the head a small *feathery tuft of gills,* like those in a fish; but not enclosed under a *gill-cover.* At this stage, the creature breathes like a *fish.* That is, the air in the water gets into the blood in the gills, and thence into the body generally, and purifies the blood. Later, it will breathe by *lungs*, like a *reptile*, *bird*, or *mammal.* The *blood-vessels* inside the frog's body soon begin to alter; and *lungs* are forming whilst the *gills* are at the same time gradually *disappearing.* A pair of tiny *fins* also make their appearance, and then a pair of *legs* behind, and lastly the pair in front; and now the creature has all its limbs. So there is no longer the need of the *tail*; that therefore gradually *disappears.* It looks as if the stuff that made the tail was used up to make *legs.* We have now a perfect *frog.*	III. Remind the class that some animals are born in a different form and state from that which they afterwards reach: and that even a *baby* is different from a *man.* Illustrate by the *caterpillar*, which becomes a *butterfly*: and ally the caterpillar to the *tadpole* stage, and the butterfly to the fully developed *frog.* Remind the children that the caterpillar is confined to *earth*, and the tadpole to the *water*: while the butterfly can move in the *air*, and the frog on the *land.* Show the class the *gills* of a *fish*, and tell them that these are used to get air out of the water for breathing. Show the class a small piece of a boiled sheep's *lung*, or a whole boiled rabbit's lung; and cut these open, to show the air-pipes, and mention their function. Draw on the blackboard pictures of the tadpole in its progressive stages of development, beginning with the *egg*, and ending with the full-grown *frog.*

NOTES OF LESSONS—THE FROG—*Continued.*

Matter.	Method.
IV. The Frog— The full-grown creature now begins to use its four limbs, by *crawling*; and jumping, or leaping, by means of its strong hind legs, on the *land*, and by going from pond to pond. Otherwise, the pond would become so full of frogs, that there would not be enough *food* in it for all the frogs that are hatched. When very young, fishes and water-birds eat a great many young frogs and tadpoles, and thus keep down the number of the frogs.	IV. Remind the class that most of the *Reptiles* previously taken lived on the *land*: and tell them that all the *Fishes*, to be next taken, live in the *water*. But the frog (*Amphibia*) lies half-way between these two Classes in this respect, living partly on land, and partly in water. It is thus said to have *two lives*; a life on land, and a life in water. The word that expresses this curious fact is "*amphibious*", or we say the frog is an amphibious creature.

100. THE TORTOISE.

INTRODUCTORY SPECIMEN LESSON.

I. Description.—There are two great branches of this family; **land and sea tortoises.**

The upper part of the **covering** is like a **buckler**; and the under like a **breast-plate**: both parts are joined together at the sides. The buckler is made of thirteen pieces of shell which overlap like the slates of a house. This shell has two openings, one for the head, shoulders, and arms to come through; and the other for the feet and the tail.

The **head** is remarkably small, with no teeth in the mouth; two bony ridges in the mouth, hard and shaped like a saw, masticate the food instead. The **jaws** are so strong that it is impossible to force them open when shut: they work like the hinges of a door.

The **legs**, though short, are strong. The animal's mode of moving from place to place is very curious, as each leg is lifted up in succession one after the other. The **claws** at the ends of the toes are fixed in the ground in walking, and thus assist progression. The legs are sheathed, like a sword in its scabbard.

II. Kinds.—(*a*) The **Land Tortoise** differs from the **Sea Tortoise** in having its shell very high on the back; its **limbs** are short and bulky; and it has horny hoof-like **claws.**

The **brain** of the Land Tortoise is very small. This creature is sometimes employed to destroy snails and other vermin in gardens; and for this purpose it is very useful.

(*b*) The **Sea Tortoise** has a longer **neck** and **tail**; **feet like fins**; and fewer divisions in its coat of mail.

In winter, both kinds hide themselves in the earth, and live a torpid life, or sleep until the return of the warmer spring.

III. Habits.—Their **movements** are very slow and awkward. They **feed** chiefly on vegetable, leaves, and fruits. The **eggs** are covered with a hard, brittle, white, shell; and are **left** by the animal to be hatched by the sun.

IV. Other Kinds.—(*a*) The other examples of this family are the **Green**, or **Edible Turtle**, so called from the colour of its fat. It is esteemed a great delicacy, and is found in tropical countries. The flesh of this creature is a great article of commerce. It weighs about two hundredweight and a half, though some have been caught as heavy as five hundredweight. It feeds chiefly on marine plants. It is gregarious, that is, it goes with others in flocks.

(*b*) The **Leather-backed Turtle** is covered with a hard skin. This is the largest of all the turtles. It is more easily taken than the green turtle. It deposits two hundred eggs at a time, laying these two or three times a year. In twenty days these are hatched: but hundreds of sea-birds destroy the young ones.

(*c*) The **Hawksbill Turtle** is the smallest of its kind, and has a sharp-pointed beak like the hawk. This creature is valuable, as it furnishes us with the **tortoise-shell** of commerce, used for fancy combs, etc. This shell consists of a series of layers. These can be separated by fire, beautifully polished, and made to look like coloured marble.

101. FISHES.

SPECIAL INFORMATION FOR THE TEACHER.

I. Classification.—Fishes belong to the **Vertebrates**; but differ from **Mammals, Birds,** and **Reptiles**:—

(1) In their **covering**, having **scales** instead of hair, feathers, or bony plates.

(2) In their means of **locomotion**, swimming by **fins**, instead of walking, flying, or swimming by feet.

(3) In their modes of **breathing**, or their **respiration**, having **gills** instead of lungs, or air-sacs; and

(4) In having **cold** instead of warm **blood** (approaching in this respect, however, closer to the Reptiles than to the other Classes).

II. Parts.—(*a*) The **head** is generally of the shape of the front of a wedge, for cutting through the water like a ship's "cutwater".

The **Lips** are horny with little or no feeling: the **Tongue**, hard, bony, often fixed, and with little sense of taste. The **Teeth** vary in size, position, number, and shape; but are generally conical and bent back, and so are not used to chew, but to hold food, the prey being swallowed whole.

(*b*) The **Gills** are placed behind each side of the head, and covered by hard **gill-covers**. They are used for breathing, fresh air being as needful to fishes as to men.

[A lighted candle placed under a glass goes out when all the air (oxygen) in it is consumed. Similarly the boiling of water drives out the air in it. A fish then placed in this dies. In a few days a fish placed in this same water could live in it, because fresh air would be again taken by it out of the outer atmosphere. In an aquarium air is forced into the water by a pumping engine, or it is freshened by a running stream.]

These gills are thin **fringes of skin**, folded to offer a larger surface to the water. Over this skin the water flows, passing into the mouth and over the gills, but not swallowed. Fishes keep their heads up stream, to prevent injury to their gills, and to let the running water pass in at the mouth and out at the **gill-slits**. The air passes through this skin of the gills into the blood; and similarly the impure gases in the blood escape into the water. The gills must be wet to allow of this; so fishes taken out of the water soon die, as the gills then dry and shrink up.

(*c*) The **scales** are supplied with oil from rows of small holes, to prevent the water getting between them. We may compare this arrangement with the "water on a duck's back" flowing over it without really wetting it; and with the down on the breast of a water-fowl. In position the scales are fixed like house tiles—embedded in the skin at the fore part, and free behind, like these. To remove the scales from a fish we use a knife from the tail to the head. The scales vary in **size**, shape, etc. Instead of scales the sturgeon has large, hard, bony plates, as most of the very ancient fossil fishes did also.

(*d*) **Fins**.—(1) **Breast fins**; these correspond in **structure**, but not in **function**, with the **fore-legs** in **Mammals**, and with the **wings** of **Birds**.

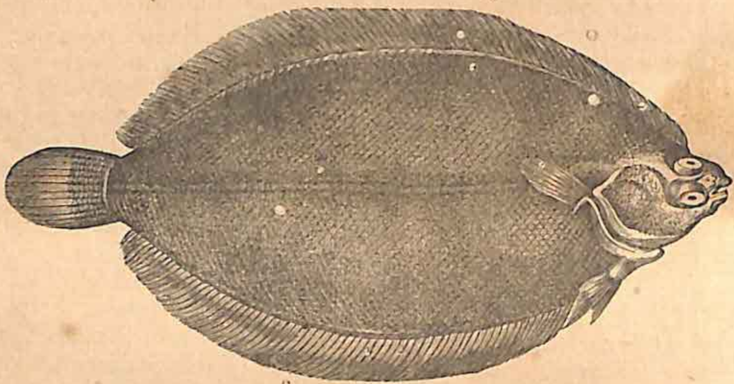
(2) **Belly fins**; these correspond with the hind-limbs of **Mammals**.

(3) **Back fins**; these are situated on a ridge, or on ridges, on the back.

(4) **Anal fins**; these are placed on the hinder part of the belly.

Fins are folds of skin strongly spread out on bony spikes, or rays; they vary in position and character with the kind of fish. The general shape is suited for rapid motion through water; and a fish may in this respect be compared with a ship or a boat. The weight of a fish nearly equals that of the water in which it swims; hence its ease in moving, as it has little weight to support or shift.

The chief propeller is the tail. This is moved from side to side; and may be compared with the sculls used by a man "sculling" a boat with an oar from the stern. The eel uses all its body for



Flat Fish—Flounder.

this purpose. The fins are used for balancing and directing the course; so if we cut off a fish's fins, the fish rolls over on its flat side.

III. The Blood of the fish is cold. Little air is contained in the water, hence there is only a slow "combustion" of the food in the fish to give heat: and the cold water would soon reduce the heat likewise.

The heart has only two chambers, not four as in Mammals, nor three as in Reptiles.

IV. Examples.—As birds are partly classified by their beaks and claws, so are fishes by their fins, as soft-finned, etc. The rays of soft-finned fishes are soft and jointed.

(*a*) Plaice and Sole—"Flat Fish."—In these the dark side is called the back, the light side the belly. They are, however, pressed sideways, like the herring, only more so, as may be understood by squeezing flat a paper bag sideways. The plaice has bright red

spots on its upper surface. The colour is just suited to its abode or habitat, in sand and mud; being like the sea-bottom on which it rests, so as to enable it to escape its enemies. The eyes are both situated on the upper side; one on the lower side would be useless. The eyes get their position by a gradual twisting of the head bones. The light side is undermost in swimming.

(*b*) **Eels** (Soft-finned).—These have many almost invisible scales. They live in the mud; so their olive green backs are unperceived. Those living on gravel beds have light-coloured bellies. The **gill-slits** are situated far back, having only a small opening, closed at will. The **gills** keep moist a long time out of the water; so eels can migrate over the land from one river, canal, or pond to another. They feed on small fishes and animal refuse, and are torpid in winter.

(*c*) **Herring.**—The true colour of these fishes is not seen when dead. They live in shoals, making the sea gleam with silvery (phosphorescent) light. They often lie on the sea bottom, being missed by one fishing boat, and caught by another after rising to the surface. They are very fruitful, 70,000 eggs having been counted in one roe. They live chiefly on fry smaller than themselves.

(*d*) **Trout** (Soft-finned).—This is one of the **salmon** family, and lives in fresh, clear, running water. The back fin is soft, fleshy, and without rays. The trout has reddish spots on the sides, and a yellow-brown back, with dark red spots on it; the lower parts are silvery white. It lives on insects and smaller fish, hence the angler must be clever to select and throw the fly, etc., for its bait.

(*e*) **The Skate.**—This has an internal skeleton of **gristle**, instead of bone. It also has a flat, broad body, mostly made up of the expanded breast fins, which are concealed by the skin.

The **tail** is slender, but in some kinds strong and used for defence. The **snout** is pointed, with a marked ridge on it.

The **eggs** are very odd in shape, like two butcher's trays one over the other, and these are often called "**skate-barrows**", because of their corners sticking out.

The skate is very voracious; it sometimes weighs 200 lbs.

V. Summary.—**Fishes** are **cold-blooded**; covered with **scales**; with a heart of **two** chambers; and they breathe by **gills**.

They are divided into two groups:—

(1) Those with **bony skeletons**; as most of our common fishes, cod, etc.

(2) Those with **gristly skeletons (cartilaginous)**; as the ray, skate, shark, dog-fish, etc.

102. THE CODFISH.

INTRODUCTORY SPECIMEN LESSON.

I. Where found.—The Codfish is common in all **temperate** seas, and is one of the most **useful** of fishes to man. The Newfoundland cod-fishery is the most valuable in the world. The fish are found round the shores of this island, but are in the greatest swarms on the **banks** lying further to the south. Great numbers are also taken on the coast of Labrador. Thousands of hands are employed in the **catching, curing, packing,** and **exporting** of this fish. The chief cod-fisheries besides that of Newfoundland are those off the coasts of the British Isles, Iceland, Norway, and Sweden.

II. Description and Habits.—In colour, the under part is white, and the back olive. It has **small scales,** and a **beard** under the lower jaw. It is the most fruitful of almost all the fishes—nine millions of eggs have been found in the roe of one of moderate size only.

The cod delights in **shallow** seas where its **food** is most plentiful. It is generally taken with a hook and line in water from 100 to 350 feet deep. Some have been taken nearly six feet in length, and weighing about a half-hundredweight. It is easily caught, as it is a very **greedy** feeder.

The fish are generally cured by being split open, salted, and dried in the sun. Fish cured in this way are often called **stock-fish.** The codfish is largely eaten in Roman Catholic countries during the season of Lent, when the people refrain from eating meat. From the liver is obtained **cod-liver oil** for consumptive and weak patients.

There are several **varieties** of the codfish on the Newfoundland shore; the one principally caught is ash-coloured, but the "coal-cod" is also abundant and the better eating of the two; it sometimes weighs thirty pounds.

III. The Cod-fishery.—The British cod-fishery has long been important, the fish being taken with long lines to which hundreds of hooks are attached. The bait is commonly pieces of other fish. Many of the English vessels are of considerable size, and have **wells** in which the fish may be kept alive for some time. Large numbers are also taken by small open boats.

At Newfoundland great numbers of the people are supported by the cod-fishery, which is carried on either by shore-boats, or else by

larger vessels which fish on the "banks" or elsewhere. The fish are generally caught by lines, but in some places nets are used.

The Newfoundland cod-fishery has been carried on for about three hundred years; yet the fish seem as abundant as when the banks were first visited. The cod forms a large part of the wealth of Newfoundland. In the summer 25,000 to 35,000 people are attracted to Labrador to carry on the fishery there. A great many French people fish on the Newfoundland banks, as well as Canadian and American fishermen.

The liver of the cod-fish yields a large quantity of oil, which is got out from it by the heat of the sun, nothing else being necessary than merely putting it into casks, and drawing off the oil when it is all drained out of the livers.

The largest boats split and salt their fish aboard; and return to their harbours when they have used up all their salt, or have got a sufficient catch.

THE VEGETABLE KINGDOM.

103. FIRST GREAT DIVISION OF PLANTS.

Flowering Plants.

SPECIAL INFORMATION FOR THE TEACHER.

Apparatus.—Specimens of grasses, with Roots; transverse section of Stem of a tree, to show rings and bark; dried Leaves, to show veins; Flowers of grasses, buttercup, and rose; Fruit of apple.

I. As **Animals** are divided into :—

(*a*) **Those with Backbones**; and

(*b*) **Those without Backbones.**

So also **Plants** are grouped into two large divisions :—

(*a*) **Flowering Plants**; and,

(*b*) **Non-flowering** or **Flowerless Plants.**

II. But animals were again first roughly divided into "Walkers", "Swimmers", "Flyers", etc., before being subdivided into :—

(1) **Mammals**; (2) **Birds**; (3) **Reptiles**; (4) **Fishes.**

So also flowering plants are again first roughly divided into :—

(1) **Herbs**; (2) **Bushes**; and (3) **Trees,** according to their **size.**

III. Herbs.—**Type: Grass.**—(*a*) These have **fibrous roots**, seen in the cluster of long root-fibres of grasses, making it difficult to pull them up without breaking. There are no stout stems nor strong branches to support; hence no need of a stout root, but only one sufficient to **supply food** to the plant, and to **fix the plant** in the ground.

(*b*) **The Stalk**, or **Stem**, is generally hollow, frequently jointed, and mostly rounded, and slender, having little weight to bear; and there is no bark which can be easily peeled off.

(*c*) **The Leaves** are long, narrow, and tapering, and often sheathing at the base. The **Veins** are nearly **parallel** in the grasses, but **netted** in many other herbs.

(*d*) **The Flowers** are many, and generally arranged on flower-stems (peduncles) coming from the stalk at intervals towards the top. The parts of the flower are generally arranged in **threes**, or multiples of three, in grasses; in **fours** and **fives** in many other flowering herbs.

IV. Bushes.—**Type: Bramble or Dog-Rose.**—(*a*) Bushes have stronger **Roots** than herbs, as they grow larger, and thus require a firmer hold on the ground for their support. The roots are branched, ending in root fibres; these fibres become **woody**.

(*b*) **The Stem** has a separable bark. It is not hollow. The wood is often in layers, round an early central pith; from it spring branches bearing leaves.

(*c*) **The Leaves** have veins like network and not parallel, as in grasses; and are often broader in bushes than in herbs, especially the grasses.

(*d*) **The Flowers** are often arranged in fours, or fives, as in the wall-flower (four), and rose (five).

V. Trees.—(*a*) The **Roots** are here much stronger than in III. or IV., having to support larger stems, many stout branches, and a thicker bark. They are branching; and, as in IV., become **woody**, but are of a much firmer kind, spreading wider and deeper as the tree grows to fix the tree more firmly, and to absorb food from fresh soil.

(*b*) **The Stem** in trees is thicker than in III. or IV., and the bark is harder and thicker. The rings of wood round the centre are often very marked, and tell the age of the tree. The branches are stouter, and support more leaves than in IV.

(*c*) **The Leaves** are generally flat expansions, sometimes erect; but in the fir, etc., become round and pointed like needles.

(*d*) **The Flower** is as in IV., but the seed box often larger.

104. SECOND GREAT DIVISION OF PLANTS.

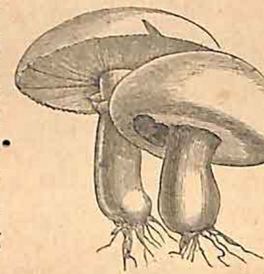
NON-FLOWERING PLANTS.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Non-flowering Plants.**—These are lower in their kind than the Flowering Plants, having no **flowers** nor **seeds**, but bodies called **spores** instead. Amongst the commonest are mildew and mould, seen growing in **damp** places, on leather (old boots left in cupboards that have become damp, etc.), cheese, jam, meat, bread, wet paper, etc. **Larger** specimens are seen in mushrooms, toad-stools, puff-balls, etc.

In both these groups, the plants are made up of **strings of cells**, either quite **white** and colourless, like long glass beads strung together; or coloured **green** (in mould), **red** (in the under part of mushrooms, etc).

II. **Mushrooms, etc.**—Some of these are **eatable**, some **poisonous**. The **eatable** ones are used for food with meat, etc., or are made into ketchup. They generally have pink **gills** (see below), changing into purple, and a "**collar**" joining the "**cap**" to the "**stem**" in early stages of growth. They are found singly, not in thick connected clusters, in open places, not in woods, and are known by the light brown or white cap, and are made up of a solid substance containing but little moisture.



Mushroom.

(*a*) **Parts.**—(1) "**Root Threads**"; these are not really **roots**, but look like the roots of some of the flowering plants. They are white, long, thread-like, brittle, and silvery; and penetrate the soil. They run together, and where they join a small round **swelling** about the size of a mustard seed is formed, which becomes larger, and thrusts itself upwards through the ground, making a "**button**", or young mushroom.

(2) "**Stem**".—Next, a "**stem**" is formed; or rather what is like one in the Flowering Plants. This is made up of bundles of the threads of which almost the whole mushroom consists, lying side by side, like the threads in a hank of cotton.

(3) The "**Cap**".—This is the spreading out of the "stem", in form like the silk of an umbrella spreading out from the stick

(the stem); only the cap at first is joined to the stem beneath by a **collar** which, however, afterwards breaks up.

(4) The "**Gills**" are the flesh-coloured **plates** on the under side of the cap, bearing the "**spores**", or what stand for seeds in the Flowering Plants. They are so-called because they are like the gills of a fish in colour, appearance, and arrangement. In due time the spores fall on the ground, and may give rise to new plants.

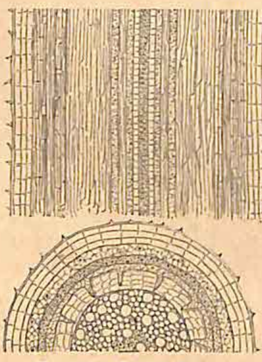
105. "INSIDE AND OUTSIDE GROWERS."

SPECIAL INFORMATION FOR THE TEACHER.

I. Introduction.—Plants are divided according to **flowers** into **Flowering** and **Non-Flowering** Plants.

Plants are divided according to **Stems** into "**Inside** and **Outside Growers**".

Plants are divided according to **Seeds** into **One (monocotyledons)** and **Two Seed-leaved** Plants **(Dicotyledons)**.



Exogen—Forest Tree.

Endogen—Palm.

A grain of wheat, when it sprouts, gives us only **one** "seed-leaf" thrusting itself out of the soil (Monocotyledon).

A pea, bean, etc., when it sprouts, gives us **two** seed-leaves thrusting themselves out of the soil (Dicotyledon).

The former belong to the "**Inside-growers**" **(Endogens)**; the latter to the "**Outside-growers**" **(Exogens)**.

II. Stems of Outside Growers (Exogens).—All Flowering Plants have stems made up partly of a soft substance, and also of harder bundles of more woody fibre.

In the "Outside Growers", a **softer** substance is at first in the **centre**, filling up a tube that runs up the young stem like the hollow of a tobacco pipe. This is the **pith**.

The outer, **woody** bundles grow round this pith and its sheath

in **rings**; and as the plant thickens by a fresh layer of this woody matter being laid down every year, or every season of growth, such plants are called **Outside Growers (Exogens).**

The **bark** also thickens every year; not on the outside, however, but from layers laid down on the inside.

If we cut the trunk of one of these trees across, we see these **rings** of wood laid down in circles round the pith, or where the pith once was. Generally, there is one ring for each year, or season of growth.

As the inner rings are older, drier, and darker than the outer, they are called "**heart-wood**" (duramen); and the moister, lighter-coloured outside rings, fuller of sap, or juice, are called "**sap-wood**" (alburnum).

The **bark** is in the same way made up of many layers, making broadly two great thicknesses; an outside and an inside one.

III. Examples of Outside Growers.—As examples of the above we may take all our forest, fruit, and timber trees; such as the oak, elm, beech, ash, apple, pear, plum, chestnut, etc.

The Outside Growers are mostly found in **temperate** and **cold** climates.

IV. "Inside Growers" (Endogens).—For picture see above. In these plants, the hard wood is not laid down in **rings**, but is **mixed up** with softer matter throughout the whole stem. No rings are seen, for instance, in cutting a cane stem across. The stems of these plants do not therefore grow much thicker in diameter; but only taller. They are also often **hollow**, as in the grasses; though not always so, as may be seen in the solid stems of the palm, sugar-cane, etc. They **have no bark**, but the outside is very **hard**. There are not often many branches to the stem.

They are mostly found in **hot** climates.

106. THE PINE TREE.

INTRODUCTORY SPECIMEN LESSON.

I. Description.—Many of you may have seen the **pine-tree** growing in England. You might know it by its tall, straight trunk rising high up into the air without branching for a long way from the ground. It is often turned it to the tall **mast** of a ship, or into a **telegraph pole** alongside the railroad to carry the wires along

which we send messages from one place to another. When so used it has had its top and branches lopped off, and its bark peeled.

Some pine-trees grow many times higher than a house. When they grow in forests, these are dark and gloomy; as the top branches shut out the light of the sky.

The leaves of pines look very different from common leaves. They are not spread out flat like those of the oak, elm, beech, or ash. They are long, and pointed, and of a dark green colour, growing together in bunches or clusters, like needles.

II. Kinds and Uses.—One kind of pine-tree is called the fir; and many of these are cut down and brought to this country for their timber, which is called deal. This is either white, or yellow, in colour. It is rather soft, so that it is not the best or most lasting kind of wood; but as it is cheap, and easy to work, we use a great deal of it for desks, tables, floors, laths, boxes, and other things.

It also burns readily in the fire; and is therefore used to make matches, and is cut up for kindling the fire, for which purpose it is well suited as it is full of resin and catches fire easily.

It is also cut down, and baked in great heaps covered over with earth, to turn it into charcoal. While this is being done tar runs out of the wood. This is made to flow into vessels; and is used to tar rails and posts, to mark sheep, and to make into cart-grease and sealing-wax after it has been mixed with other things.

You will see great piles of pine-wood at ports on the sea coast, where it is brought from other countries into England. From these places it is taken by railroads to every town in this country. As pine-wood, or deal, is the cheapest kind of wood, it is that which is most used. But the dearer kinds of wood, such as oak, ash, and beech, last longer, and so are the cheaper in the end.

107. FLOWERING PLANTS.

SPECIAL INFORMATION FOR THE TEACHER.

A Plant;—Type: A Buttercup.

Parts I.—For the growth of the plant itself.
II.—For preparing seeds, for new plants.

I. Concerned in Growth.—(*a*) Root. This is the "descending axis", as this part goes into the darkness, and into the soil, branching through it to find plant-food (water, and what water holds in solution). It has no pith, no bark, no leaves.

(*b*) **Stem.** This is the "**ascending axis**"; it goes into the **light** and air, bearing at intervals the leaves and flowers, singly, in pairs, in clusters, or in whorls, etc.

(*c*) **The Leaves.** These consist of :—

(1) A flat portion called the **blade (lamina).**

(2) The leaf-stalk (**petiole**).

Leaves take in much of the plant-food from the air, and elaborate it, as they do also that absorbed by the roots.

II. For preparing Seeds.—(For new plants.) The flower does not help to feed the plant. It provides seeds, and generally consists of :—

Two "Flower-cups";

(*a*) The **Outer**, often green,

(*b*) The **Inner**, coloured.

The **Outer** floral envelope is the **calyx** made up of individual **sepals**; the **Inner** floral envelope is the **corolla**, made up of individual **petals**.

Both these protect their inner contents, viz. :—

(*c*) **Stamens.** These are thread-like "dust-spikes", or stalks with sac-like swellings at the outer extremities. These sacs are filled with "flower-dust" (**pollen**), gathered by the bee for "bee-bread".

(*d*) **Pistil.** This "seed-box" in the centre of the flower consists of :—

(1) **Seed-vessel**, with young seeds (**ovules**).

(2) **Stalks.**

(3) **Head (stigma)**, round, flat, triangular, etc.

Some of the four preceding items (*a*)-(*d*) may be **absent**; but there are always in flowering plants :—

(1) The sacs on the stamens, with pollen.

(2) The seed-vessel, either on the same plant as the stamens, or on a different one from this.

(*e*) **The Fruit** is the enlarged, ripened, seed-vessel : or this and other parts connected with it. A cut apple or orange shows pippins or seeds in a **fleshy** fruit. A buttercup shows a single **dry** seed each in a separate seed-box, but many of these clustered together in one flower.

108. FLOWERLESS PLANTS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Introduction.—Plants are divided into :—

(1) **Flowering** Plants, with **Seeds**

(2) **Flowerless** Plants, with **Spores.**

The latter are the **oldest** inhabitants of the earth; the **first** that spring up on new sites; and the **simplest** in structure. They are divided into :—

(1) **Fungi**; type, mushroom.

(2) **Lichens**; mostly flat, coloured expansions on rocks, etc.

(3) **Mosses** ("**Musci**"); generally growing on damp soils, rocks, etc.

(4) **Water Plants** ("**Algae**"); sea-weeds, river-weeds, pond-weeds, etc.

(5) **Ferns** ("**Filices**"); sometimes growing into trees sixty feet high.

Besides are other less important subdivisions.

All are more or less **cellular** (some consisting of a **single** cell, as in the yeast plant); a few having denser tissue, as in the "roots" ("mycelium") and leaves ("fronds") of ferns.

All have "**spores**" instead of seeds.

II. Fungi.—**Mushroom Type.**—These appear in the mushroom as fine swellings on white threads ("**spawn**"), which give rise to a "**stem**" (stipes), "**cap**" (pileus), and "**gills**", on which are "**spores**".

The mushrooms are either **edible** or **poisonous**.

Still lower types of the Fungi are mould; the "vinegar plant"; yeast cells; puffballs; dry rot; mildew, smut, and rust of wheat; the blight of the hop, potato, and vine, etc.

The fungi are very **wide-spread**, as the spores, being light, and often microscopic, are readily borne by the wind everywhere. These develop on almost any **organic** (vegetable or animal) substance that is dead, and where moisture is present.

III. Lichens.—These are mostly found in **dryer** situations than the others; and specially on timber, stones, etc.

They make scaly, leprous-looking incrustations of yellow, brown, and parti-coloured patches.

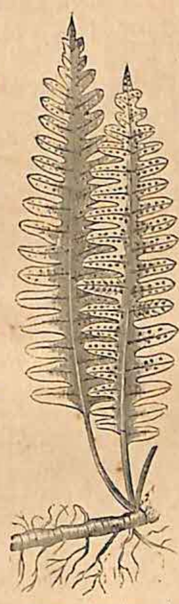
IV. Mosses.—These flourish on **damp** soils, rock-faces, etc., and are frequently **green**. They often have little **stalks**, some with **urn-like** vessels at the top. They grow in **masses**, not solitary; and disintegrate even hard granite, and thus form the first vegetable soil, for higher plants to grow in afterwards.

V. Aquatic Flowerless Plants: Algae.—These grow in both **fresh** and **salt** water :—in rivers, lakes, and ponds, and in the sea. In tropical seas they grow in long fronds of many feet in length. They are mostly olive, rose, or green in colour, as in the **seaweeds** of our own shores and rock-pools (sea-wrack, tangle, etc.).

The "gulf-weed" of the Atlantic Sarghasso Sea misled Columbus into thinking that he had arrived very near to land.

VI. Ferns: Filices.—These may be small, or, in the tree-ferns, sixty feet high. The "**stem**" is either **underground** ("rhizome") as in bracken; or **erect** as in the tree-ferns. The "**fronds**" ("leaves") are, often crozier-like, expanding from a spiral; and "**pinnate**", or subdivided on both sides of the central "rib".

The **spores** grow in clusters on the under side at the margins, or on the "ribs" of the fronds. Among the commoner sorts are the common brake or bracken, the polypody, adder's tongue, maiden hair fern, etc.



Fern showing two Fronds with spore-cases on their surface.

Bracken.—This has large green "leaves", a stem-like axis, with offshoots and leaflets. We can follow the stem-like axis into the embedded portion, towards what is not the root, but an underground stem. We should note the true root given off by this creeping stem, and examine this. In one direction we see the withered bases of leaves now dead; in the opposite direction, we find a rounded extremity with hairs, viz., the growing point. We also note the leaf, now small, which will develop in years to come.

In full-grown "leaves" we see the turning in of the edge of the leaflets; the hair-like processes; the spore-boxes in the groove formed by the inturning edge. These **spore-boxes** contain many **spores**.

If we cut across the creeping, underground **stem**, we note an outer dark zone; an inner white substance; various patches of dark brown, and others of a pale yellow. If we cut a longitudinal section, we again see these. The growing point is paler and softer. The **white** contains the simple food-stuff ready to be used by the plant. The **dark** bands are strengthening fibres (the "bones"). The **yellow** parts contain the vessels through which the food passes.

If the **spores** fall into a warm, moist soil, they grow into very small green plants, which develop a powdery "dust" on the top, something like dust-spikes and seed-box, and from these the young fern is formed. These parts, however, are exceedingly small, and need a microscope to examine them. The spores are

not really true seeds, but form a simple plant which will produce a fern.

109. FLOWERING AND NON-FLOWERING PLANTS (CONTRASTED).

SPECIAL INFORMATION FOR THE TEACHER.

Introduction.—Geranium and Fern.—These may be taken to represent the **flowering** and **flowerless** types respectively.

I. (*a*) In the **Flowering Plants** we find **roots,** or rootlets; **stems,** underground or above; **stalks**; **leaves**; and **seeds.**

(*b*) New flowers develop from the **seeds.** Seeds only form when some of the dust of the dust-spikes falls on the top of the seed-box. To form a fruitful plant the dust should generally be that from **another plant of the same kind.** The carrying of the dust is in large measure done by insects, which appear to be attracted by the bright colours, by the scent, or by the nectar found in the flowers.

II. In **Flowerless Plants** we do not find any "**seeds**" formed in the same way as in (*b*); and perhaps that is why these plants have no bright flower-leaves. They have what correspond to Stems and Leaves, though these are known by other names (**Stipes** and **Fronds**).

110. NOTES OF LESSONS—FLOWERING PLANTS.

Apparatus.—Flowers of the geranium, rose, wall-flower, daisy, buttercup, and lily.

Matter.	Method.
I. Parts of the Flower— The *parts* of the flower are arranged more or less in four circles:— (*a*) *Protecting Leaves,* generally green. (*b*) *Flower-Leaves proper,* or *coloured leaves* of flower, generally coloured (that is, not green).	I. (*a*), (*b*) Compare the two outer "*whorls*" of the flower with the *great-coat,* and the *under-coat* of a man: both are useful to keep out the *wet* and *cold* (wind). But these garments both open in front, whereas in flowers, one opening often comes where the other is absent.
(*c*) The *Dust-Spikes,* generally consisting of small stalks, with little bags at the top full of coloured "dust", or pollen.	(*c*) Shake out the *pollen grains* of a ripened flower on a slate, to show their yellow colour.
(*d*) *Seed-Box,* full of white seeds (unless when very young). The two outer circles (*a*) and (*b*) may consist of *separate* parts, or be *united* into a tube, etc.	(*d*) Let the class make a collection of "*pistils*", including pea-pod, poppy-head, etc. Keep them together in a box, dried, for illustrations; and add to them from time to time.

NOTES OF LESSONS—FLOWERING PLANTS—*Continued.*

Matter.	Method.
These outer circles, especially the first, are *most* leaf-like, the inner seed-box, the *least* so; but even in the pea-pod the form of the leaf is seen.	Run through the *whorls* from the outside to the inside, to show the greater and greater modification of leaf-form, in colour and structure (in rib, veins, etc.).
The *colour* and *scent* are useful to attract insects to carry off pollen, nectar, etc.	Tell the class that insects carry the pollen with them from one flower to another, and so make seeds *fruitful*.
The top of the flower-stalk is sometimes enlarged into a flat *disk*, as in the dandelion.	Make collection of Compound Flowers (*Compositae*), with disks and florets, including asters, everlastings, dahlias, sunflowers, etc.
The *outer* circle is generally present. Sometimes the *second* circle is absent. Either of the *next* two circles (*c*) and (*d*) may also be absent. A flower may consist of only dust-spikes (*c*), or seed-box (*d*).	Show examples of all these. Point out in the lily tribe (tulip, etc.), that there are six flower-parts; but really two pairs of these. Show in cucumber or vegetable marrow flower, the two inner whorls on *separate* flowers, on *same* plant.
II. Classification— If we examine many flowers, we see that some are *like* others; and so we divide flowers and plants into different *divisions*, the members of which are *alike*. Of the very many such "*Orders*", as we call them, we select the following as most common types:—	II. Explain the *necessity* of this by referring to dividing children in school into classes, or *standards*. Show that there is a *likeness* by placing together two or three flowers of each of the Orders set down below. Ask the children to bring to school, in seven separate groups, the following flowers under their *types*:—
(1) *Buttercup* (Ranunculaceae).*	(1) *Buttercup*, clematis, anemone.
(2) *Wall-flower* (Cruciferae).	(2) *Wall-flower*, wild mustard, cabbage, turnip.
(3) *Daisy* (Compositae).	(3) *Daisy*, dahlia, sunflower, dandelion.
(4) *Rose* (Rosaceae).	(4) *Wild rose*, blackberry, strawberry, cherry, apple, hawthorn.
(5) *Lily* (Liliaceae).	(5) *Lily*, tulip, onion, hyacinth.
(6) *Grass* (Gramineae).	(6) *Grasses*, wheat, oat, barley.
(7) *Pea* (Leguminosae).	(7) *Pea*, bean, scarlet-runner.

111. A FEW ORDERS.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Introduction.**—There is an almost infinite number of known species of plants. We are, therefore, obliged to **group** these into divisions, according to their likeness to each other.

First, we have **Individuals**; then **Varieties** (or groups of individuals much alike); next **Species** (or groups of varieties, not so much alike as in the preceding); then the **Genus** (or groups of species); and **Orders** (or groups of genera).

* The botanical names of the Orders are for the teacher only.

These divisions are partly natural; and partly artificial; the artificial classification is based on a few organs;—the natural (and therefore the better one), on all of these.

II. Buttercup Order (Ranunculus Tribe).—Type, the Buttercup.

This order includes the buttercup, anemone, clematis, monkshood, larkspur, columbine, etc. The plants of this order are nearly all herbs (not bushes, nor trees). Very many are poisonous (as the monkshood, etc.).

The numbers of whorls to the flower is four generally; with five divisions to the two outer whorls (calyx and corolla).

The fruits are sometimes one-celled, and one-seeded ("achenes"), as in the buttercup; sometimes a berry.

The flowers are many-coloured and very various in shape.

III. Cross-Bearers (Cruciferae).—Type, Wall-flower. This order includes the cabbage tribe, candytuft, shepherd's purse, stock, mustard, watercress, turnip, radish, horseradish, etc. They are mostly herbs; frequently good for food; and useful against scurvy (anti-scorbutic).

The calyx and corolla generally consist of four (not five) parts; opposite to each other, in the form of the Greek cross, whence their name (crucifers, or cross-bearers). The flowers are generally at the end of the stalk ("terminal"), and yellow or white in colour; but colour is the least distinguishing mark of flowers, and the most altered by cultivation, etc.

IV. Compound-Flower Order (The Compositae).—This order is a very large one, consisting of 10,000 species, or about $\frac{1}{12}$ of all the species in the world. It includes among the commonest members the daisy, thistle, ragwort, dandelion, lettuce, blue-bottle, marigold, sunflower, coltsfoot, etc.

The flowers are compound, or made up of many florets, generally arranged on a flat disk on the stalk; the outer circles ("ray-florets") being generally larger than the inner ones ("disk-florets").

The separate florets are either,

(1) Strap-shaped, as in the ray-florets of the daisy, or

(2) Tubular, as in the disk-florets of the daisy.

They are mostly herbs, or shrubs.

Not many are useful; but most are ornamental.

V. The Rose Order (Rosaceae).—This order is very large, and includes very many fruit trees, specially those growing in warm temperate climates, as the apple and pear; blackberry, straw-

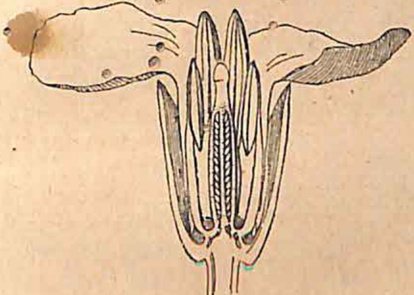
berry, and raspberry; cherry; apricot, and plum, etc. In addition, there are ornamental shrubs, as the rose, hawthorn, etc.

This order includes three large divisions; and a smaller one—

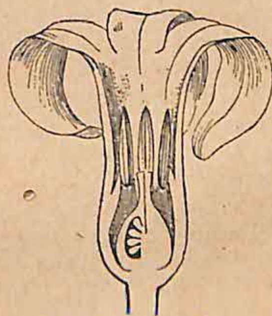
(1) The Rose Tribe.
(2) The Cherry Tribe.
(3) The Apple Tribe.

There are generally five separate parts to the corolla; and the flowers are generally regular in shape.

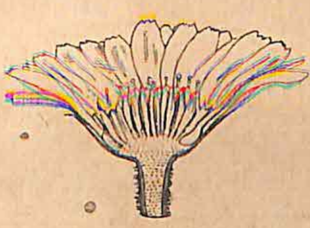
VI. The Lily Order (The Liliaceae).—This order brings us to flowers of which the two outer whorls consist of three separate



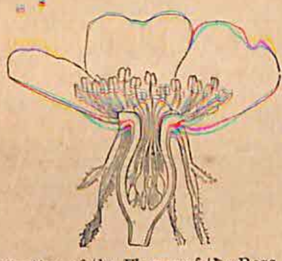
Section of Wall-flower.



Section of Flower of the Hyacinth



Section of Marigold.



Section of the Flower of the Rose.

parts each (six in all); with six dust-spikes (stamens), and a seed-box (pistil) in three chambers. That is, three is the typical number of the construction.

It includes the wild tulip, crown imperial, ordinary lilies, leek, hyacinth, and asparagus. They are generally herbs, or shrubs. They are often propagated by bulbs, corms, and rhizomes (*vide supra*).

The leaves are mostly lance-shaped; and the flowers solitary, or single; the seed-box (ovary) rises up from the floor of the flower-stalk.

VII. The Grasses (Gramineae).—These are very numerous; very widely spread; and most important as food for men (cereals), and of beasts (hay, grass, etc., for fodder). They are mostly herbs, but the bamboos are trees. They include the cereals (wheat, oat, rye, maize, rice, barley); meadow grasses, rye grass, bamboos, and sugar cane.

The flowers have three stamens (dust-spikes); the stems are generally hollow, and jointed; and the leaves "sheathing". The anthers (the pollen-pouches at the top of the stamens) are frequently "versatile", or balanced at the centre of gravity, so as to swing lightly with the wind.

VIII. Leguminous Plants (Leguminosae).—These also are very important for food to man and beast; the seeds of the pea, bean, and lentil being very nitrogenous from the "legumin" they contain.

Some are herbs, but many shrubs and trees.

The order includes the broad (Windsor) bean, and scarlet-runner; the dwarf, or French bean; the garden and sweet pea, furze and broom, clover, indigo, laburnum, etc.

Many of these have pods for pistils; so the fruits and flowers are a good index of the order.

The flowers are very characteristic; and in one subdivision are called papilionaceous, from their fancied resemblance to a butterfly, as in the pea. The corolla consists of five parts, of which two are "wings", two make a "keel", and one a "standard"; the dust-spikes are ten (a multiple of five). Stipules, or modified leaf-forms on the flower-stem, are very frequent.

112. NOTES OF LESSONS—THE BUTTERCUP.

Matter.	Method.
I. Description—	
(*a*) Here the flower is "*regular*"; that is, the parts in the coloured leaves (corolla) are alike in number and in shape.	I. (*a*) Contrast this with the "*irregular*" flower-leaves of the second circle in the pansy.
(*b*) There are five *protecting-leaves*, and five *flower-leaves*.	(*b*) Contrast this with the *three* of each in *lily*, and the *four* in each of *wall-flower*.
(*c*) There are *many dust-spikes*; whereas in lily there are only the	(*c*) Contrast this with the *wild rose*; and show from specimens that this

NOTES OF LESSONS—THE BUTTERCUP—*Continued.*

Matter.	Method.
"proper" number (three), determined by the number of parts in the outer circles.	*multiple number* of parts in the third circle is very common in flowers.
(*d*) These dust-spikes do not *spring* from the flower-leaves, but from the thickened end of the *flower-stalk*. This is a very important point to notice, though it seems such a small thing.	(*d*) *Compare* this with flowers where the dust-spikes are similarly "*inserted*"; and *contrast* them with those in which they spring from the "*petals*"; and insist on this difference as an important one.
(*e*) There are *many* and *separate* seed-boxes, growing on the end of the flower-stalk, and each containing one seed only.	(*e*) Compare the *number* with many pea-pods growing on one stalk, and contrast the separate pistils with the single one of a poppy-head.
II. Relations— The *bramble* is a similar flower in having the same number of "protecting"- and "flower"-leaves, many dust-spikes, and separate seed-boxes; but yet it belongs to a *different order*, because of *other* differences. But the anemone, and marsh marigold are relations to the buttercup.	II. Ask children to bring to school as specimens the common buttercup, and the marsh marigold found in damp situations. *Compare* and *contrast* these: the flowers are similar, the *shape* of the leaves different. The *colour* is also alike, but that is not a very important point in flowers.

113. NOTES OF LESSONS—THE WALL-FLOWER.

Matter.	Method.
I. Description— (*a*) Here the flower is rather *irregular* there being four outside leaves to *six* dust-spikes, and the flower-leaves are of different *sizes* and slightly different *shapes*.	I. (*a*) Point out to the class that to get six out of four, two must divide. When eight in one circle are found with four in another, the four have each split up into two.
(*b*) Of the four *protecting leaves*, two are "*inserted*" *lower* than the other two, or on a lower level.	(*b*) Tell the class that we use the word "*inserted*" in speaking of plants, to mean "*springing from*".
(*c*) There are four *free flower-leaves* each of which may be pulled away separately, without disturbing the others.	(*c*) Tell class that "*free*" means separate, not united into a tube; and illustrate by the petals of a wall-flower, contrasted with the tube of a Canterbury bell.
(*d*) There are *six dust-spikes*, of which two are *shorter* than the other four.	(*d*) Show in the specimen that these two are "*opposite*" the outer protecting leaves.
(*e*) There is a double *seed-box*, with two divisions in it, and a short stem and knob on the top of it.	(*e*) In a ripe seed-box of the wall-flower (siliqua), show the class the dividing *membrane* between the two compartments.

NOTES OF LESSONS—THE WALL-FLOWER—*Continued.*

Matter.	Method.
II. Relations— Point out that the distinguishing marks of this tribe are very easy to note; specially the *four* flower-leaves, in *opposite* pairs, or arranged like a *cross*; whence their name of *Cross-bearers*, or *Cruciferæ*, or Crucifers.	II. Ask children to bring to school, as many *garden* and *field* specimens of these as they can find. These should include the wild mustard, from the hedge-side, the cabbage, radish and cress from the garden, and rape from the field.

114. NOTES OF LESSONS—THE DAISY.

Matter.	Method.
I. Description— (*a*) This is a *Compound Flower*; that is, it is made up of many separate *florets*, clustered together. It is thus the opposite of *single* flowers.	I. (*a*) Let each child bring two or three *specimens*, to establish the points indicated below. Get from the class that a "*floret*" means a little flower.
(*b*) These are packed close together on a *disk*, or head.	(*b*) Pull out the disk-florets of a *dandelion* to show this.
(*c*) This disk is a *flattened expansion* of the flower-stalk, which thus gives greater room for the florets.	(*c*) Show a disk of a *ripe* dandelion from which the florets have fallen.
(*d*) There are *two sorts* of florets thus arranged— (1) An outer ring, of "*ray-florets*". (2) An inner cluster of "*disk-florets*". The outer florets are white in colour, and the parts of each are united together, forming a tiny flat *strap*, with no dust-spikes, so that we call them *irregular*. The *inner* florets are yellow in colour, and each consists of parts united together forming a *tube*, and with dust-spikes on them.	(*d*) *Dissect* these out separately in a daisy, dahlia, sunflower, etc., and get the class to do the same with one of their specimens. Explain that the *ray-florets* are so called because they spread out like the *rays* of the sun in a picture of it. Explain that we call these *straps* because they are long and narrow. Remind the class that the preceding florets were *straps*, not *tubes*. Show both under a small magnifying glass, or cheap simple microscope.
(*e*) The *seed-boxes* are at the bottom of each floret, and contain one seed only.	(*e*) Ask the class to find these out for themselves; but it will require sharp eyes to do so.

115. NOTES OF LESSONS—THE ROSE.

Apparatus.—Wild rose, cultivated ditto, dried rose-hips, specimens of other examples of the Rose Order in flower.

Matter.	Method.
I. Description— (*a*) The flower of the wild or dog-rose is "*regular*". (*b*) It consists of *five protecting-leaves*, of a green colour, and enclosing a *seed-box* below, and *divided* above. (*c*) It has also *five flower-leaves*, of a pale *pink* colour, each free, or separate from its fellows on the same whorl. (*d*) There are *many dust-spikes*, and they spring from, or are *inserted* on, the protecting-leaves of the flower. (*e*) There are *many seed-boxes*, which are *enclosed* in a cavity formed in the top of the flower-stalk (peduncle).	I. (*a*) Let each child have two or three *specimens* of the wild dog-rose flower to dissect. (*b*) Let the children *pluck off* these separately, to *uncover* the seed-box below: and ask them to *count* the divisions in the whorl. (*c*) Compare all these with the *many flower leaves* of the *cultivated* rose: and contrast them with these in *colour*. (*d*) Ask children to discover for themselves the points of insertion of the *dust-spikes*, and to note the colour of the pollen. (*e*) Remind the class that the *seed-boxes* of the preceding Orders were all *above* the level of the insertion of the protecting-leaves.
II. Relations— These are very *many*, and include several of our *fruit* trees and bushes, *e.g.*, apple and pear: the berries, (blackberry, strawberry, raspberry, etc.): the plum, etc. This gives these chief divisions: (*a*) *Rose Tribe.* (*b*) *Apple and Pear Tribe.* (*c*) *Plum and Cherry Tribe.*	II. Let the children bring the flowers of as many of these as are in season, the teacher asking the preceding noon at school for them to do so. Substantiate on all the *specimens* the points indicated in the *Description*: and note any points of *difference* in any respects between these and the rose taken as the *type* of the *Order*.

116. NOTES OF LESSONS—THE LILY.

Apparatus.—Bulbs of lily, tulip, and hyacinth, and flowers of these. Onion, and leek.

Matter.	Method.
I. Description— (*a*) The flower is *regular*; the number *three* being the key to the structure of the flower. (*b*) Here are three *protecting-leaves*, but these are *white*, or	I. (*a*) Call particular attention to the regularity of the number of parts in the circles in this Order. (*b*) Explain the meaning and use of the word "*alternate*", in speaking of parts of

NOTES OF LESSONS—THE LILY—*Continued.*

Matter.	Method.
mostly so, not green. They rise between the flower-leaves, and are inserted at a rather *lower* level than these.	plants, as referring to "intermediate" between other parts; and "*opposite*", as in front of others.
(*c*) There are also three coloured *flower-leaves*, but these are exactly like the preceding, except that they are "*alternate*" with them, or between each pair of the preceding; and inserted at a slightly higher level. Unlike all the preceding Orders, (*b*) and (*c*) in this Order are almost entirely *alike*: and so they are generally regarded as *one* circle popularly.	(*c*) It will be some time before the children abandon the notion of six *flower-leaves* in one circle, instead of the two circles (*b*) and (*c*), in this Order. Try to get the children to discover for themselves the differences of level of insertion of (*b*), (*c*), and (*d*). Pulling a tulip to pieces will aid, as this is of *large size.*
(*d*) There are also six *dust-spikes*, three of which are also below the level of the other three. These grow from *beneath* the seed-box, at the end of the flower-stalk.	(*d*) Explain to the class that six is a "*multiple*" of three: and that nine, twelve, etc., are other multiples of the same typical number three in the Liliaceae.
(*e*) There is one *seed-box*, but this has three divisions inside, and contains many seeds.	(*e*) Ask class to note the same in all the *seed-boxes* of the specimens, as seen both from the outside ridges and inside divisions.
II. Relations— These include *herbs*, such as the onion and leek; and ornamental garden and *window plants*, such as the hyacinth, etc., and other plants propagated by *bulbs* and *corms*, as seen in the seedsmen's shops.	II. Show class some *bulbs* of this division of plants, and cultivate such in hyacinth glasses; and, for tulips, in garden pots. Refer, for further illustration, to the structure and sprouting of an onion.

117. NOTES OF LESSONS—THE PEA.

Apparatus.—Pea and bean blossoms, laburnum and furze ditto.

Matter.	Method.
I. Description— (*a*) The flower here is regular in the *number* of parts in the circles; but there is irregularity in the *shape* of the separate flower-leaves.	I. (*a*) Let children bring specimens of furze blossom, sweet-pea, garden pea, kidney-bean, French or dwarf bean, or laburnum flowers; and point out their agreements.
(*b*) It has five *protecting-leaves*, of a green colour.	(*b*) Show these in a dried condition on a pea-pod.
(*c*) The five *flower-leaves* are very peculiar and marked, in the Order.	(*c*) Pluck off the "*wings*" first, to give two out of the five parts: next pull off

NOTES OF LESSONS—THE PEA—*Continued.*

Matter.	Method.
Taken as a whole they look like a *butterfly*; and two of the parts are called "*Wings*", because of this; and the flower as a whole in some of the members of the Order is called by a name which means "like a *butterfly*". The under part of this circle consists of two parts joined together, which make the shape of a *boat*, with a *keel*;—and this part is called by a word which means *keel*. The top part of the coloured portion of the flower, is like a *hood*, or a flag and gets its name from the *Standard* or battle-flag of an army. This turns round with the wind, and keeps off the wind and wet from the pollen grains inside.	and divide asunder the "*keel*", to make two more parts: this leaves the "*Standard*". Explain how the wind turns this as it does the weather-cocks: and call attention to a whole field of peas in flower, with the *standards* directed all one way by the wind. Float on a saucer of water the undivided "*keel*" of the flower, to show its boat-like shape. Compare the flowers of all the *specimens*, to show that in all there are these five parts; and that they are all similarly shaped. The furze blossom will be met with nearly all the year round.
(*d*) There are ten *dust-spikes*, or a multiple of the five in the preceding circles (*b*) and (*c*).	(*d*) Let children find out for themselves that these ten *dust-spikes* are arranged as nine and one.
(*e*) The *seed-box* is a single pod, and the seeds in it are arranged alternately in either half of it.	(*e*) Break open a full *pea-pod* to show this, and point out that this arrangement gives room to *each* for itself.
II. Relations— These include many garden plants used for *food* for man and beast, as peas and beans; also *wild shrubs*, as the furze; and *cultivated* ornamental trees and shrubs, as laburnum, etc.	II. Tell the class that as the *cereals* are the most useful plants for the food of *man*; after the *grasses*, the *pea and bean* tribe are so for *dried fodder* for *animals*.

"PHENOMENA OF THE EARTH AND ATMOSPHERE."

At this stage we part from the Animal and Vegetable Kingdoms, to be resumed in an advanced direction in the next Standard, Part IV., and turn to the *Mineral* Kingdom, and to Natural Phenomena generally. At first the Phenomena of the Earth will be dealt with, in continuation of the Natural Phenomena of Parts I. and II., and afterwards the Phenomena of the Air.

118. NOTES OF LESSONS—SOLIDS, LIQUIDS, AND GASES.

Apparatus.—Clay, sandstone, slate; sealing-wax; glass of water; oil; treacle; matches, paper, and tumbler to make and collect smoke; nitric acid and copper, to make red fumes; a glass rod.

Matter.	Method.
I. Introduction— Everything on the earth is found in one or other of *three forms* or *states*;—it must be a *solid* as ice; or a *liquid*, as water; or a *gas* or vapour, as "steam". Each of these is made up of a great number of very small particles, thousands of times finer and smaller than powdered chalk. These small particles are called "*atoms*".	I. Ask for the *general* properties (as *colour*, *taste*, *smell*, whether they *burn* or not, etc.), of the above substances mentioned in "Apparatus". Note that some form "*pieces*", or "*lumps*" of varying size and shape, and others "*drops*", which run like water. The former are called *Solids*, and the latter *Liquids*. Ask class for other instances of each of these two states which are not included in the list of "Apparatus" suggested above.
II. Solids. Properties— (*a*) The *Solids*, unless pressed into other and different shapes, remain of the *same shape*; while the *Liquids* can be made to take any shape we wish, by pouring them into differently shaped vessels. (*b*) In a solid the particles are held *closer together* than in a liquid, as a rule. (*c*) Solids can *stand alone* without support, without "running" or "flowing" away. (*d*) Solids can often be *turned into liquids* by the application of heat, of the sun, a fire, a lamp, etc.	II. (*a*) Get from the class as many properties of Solids and Liquids as possible, and then divide these properties into two groups, those belonging to water taken as a type, and those like the properties of clay, etc. Show that solids always have the *same* shape by moving them, turning them, etc. (*b*) Explain the meaning of the word "*particles*"; show in dust, flour, etc., instances of small particles. (*c*) Put a solid on the desk, to show that it will stand without support. (*d*) Turn ice into a liquid by melting it (heat), or light a candle and call attention to the wax melting.
III. Liquids— (*a*) Will flow, or easily move; and the particles are not so close and tight together as in Solids. They take the shape of the vessel into which they are poured. (*b*) They have a *level surface*, except so far as wind may affect. (*c*) They form *drops* which hang together, and also cling to solid substances, or *wet* them. By crushing a piece of stone, chalk, etc., we see that it takes *force* to break up this mass into particles. These particles must	III. (*a*) Change the shape of water by pouring it into jars, cups, etc. Press with moderate degree of strength on a lump of sandstone, and it does not alter its shape; do so with water and it does alter. (*b*) Call attention to the flat (level), table, etc., or level surface of a pond, etc. (*c*) Dip the hand into water, and drops will fall from the fingers. Contrast with solids in this respect. Ask for a list of Solids and also of Liquids. Let a child break up on a slate before the class a small piece of crumbling stone,

NOTES OF LESSONS—SOLIDS, LIQUIDS, AND GASES—*Continued.*

Matter.	Method.
therefore be held together by some other *force*. But we can easily displace water, and other liquids, by moving our hand through them with very little force. *Liquids*, therefore, are held together less forcibly than solids. But our experiment shows that this *binding force* varies with the solid substance, being great in "hard" ("*tenacious*"), substances, such as iron, etc., and weak in "*brittle*" substances, such as chalk, coal, etc. There is something of this same difference in liquids also, as in easily moving (*fluent*) water, compared with sticky ("*viscous*") treacle, etc. In the case of both Liquids and Solids, we see that the mass is made up of *particles*. But we have also reason to believe that these particles are again made up of very much smaller particles ("*molecules*") too small to be seen even with the microscope.	or chalk; and a piece of hard granite, or a pebble. Next let a child beat up a little water in a vessel with a spoon, or a stick. Contrast digging the ground, and paddling with a canoe. Write on the blackboard in two columns, headed "Tenacious" and "Brittle", lists of substances given by the class in these two divisions. Suggest other substances; and ask class under which head they should be arranged. Do the same with liquids under the heads of "Sticky" and "Not-sticky". Take a lump of sugar, and show that it can be broken into smaller lumps. Do the same with one of these again and again, and show that there is no end to our subdivision, until we come to pieces too small to be seen with the naked eye.
IV. Gases— (*a*) Solids and Liquids can often be turned into *gases* by heat, as when we throw a candle into a fire. (*b*) The particles are very far away from each other, in a gas. A little escape of gas therefore is soon smelt all over a room. (*c*) They cannot *stand alone* like solids; but if heavy, sink down to the lowest level; if light, rise up. (*d*) Gases spread out in *all* directions, unless shut up in vessels. (*e*) They do *not* form *drops* like liquids: a bladder of air remains gaseous under ordinary degrees of cold. (*f*) They can be sometimes changed into liquids by cold.	IV. (*a*) Change a piece of ice into water; and then to "steam". Or light a candle: the flame is *gas* burning. (*b*) As the particles are very far asunder, the gas is *light*. Being *light*, it generally rises and spreads out all over the room. (*c*) The distinguishing mark of both gases and liquids is that they will not take fixed and constant shapes. (*d*) Burn brown paper under a tumbler, and raise the latter and let the smoke and gas escape. (*e*) Breathe on a slate; the moisture in the breath changes to water, by the cold slate condensing it; but the gases do not condense to a liquid. (*f*) The steam must stand as a representative of this property.
V. Illustrations— *Coal gas* comes out of a pipe with great force when the tap is turned. This gas *spreads* all over	V. Pour some nitric acid on copper filings. Note the red fumes or gas that rises.

NOTES OF LESSONS—SOLIDS, LIQUIDS, AND GASES—*Continued.*

Matter.	Method.
the room; it does not take the *shape* of an open containing vessel as a liquid does, or a permanent stable form like a solid. This is because the particles get as *far away from each other* as they can: or "*drive*" each other away. In a solid they "*attract*" each other: in a liquid they merely hold together weakly. *Heat* increases this driving *apart*, so that gases "expand" or spread with it. *Cold*, of course, does the reverse; it contracts the gas, or brings its particles closer together. If the *solid* be heated it turns to a liquid; if the *liquid* be heated it turns to a gas; if the *gas* be heated it becomes expanded, or occupies more space. And (*reversely*) the *gas* can be cooled into a liquid; and the *liquid* frozen into a solid; as in the well-known case of "steam", water, and ice.	Refer to steam from the mouth of a kettle here standing for a gas; or turn on the gas-tap, and allow the gas to escape for a moment into the room, or better still into a paper bag, or bladder of skin. Illustrate the points in "Matter" column by reference to— (*a*) *Vapour*, in clouds in the sky. (*b*) *Water*, in the ocean beneath. (*c*) *Ice*, in icebergs, glaciers, ice-floes, ice-fields, etc. Show these changes by simple experiments with *ice* in a saucepan over the fire, being turned into *water*; and by boiling this water until it all escapes as *vapour* into the air. Tell the class that even the *air* itself can be made to take a liquid form, when it looks like water with a tinge of blue colour to it. Remind class that we cannot get cold or heat enough to change the "state" of *all* substances.

119. NOTES OF LESSONS—POROUS BODIES.

Apparatus.—A tumbler, piece of cane, spirits of turpentine, blotting paper, flannel, sponge, candle, some pieces of wick, bread, lump sugar, charcoal, and chalk.

Matter.	Method.
I. Cane— If a piece of *cane* be placed in spirits of turpentine, and after a time taken out, it will give a flame if a light be applied to it. This is because the cane is full of *holes* or *pores*, which are now filled by the turpentine which burns with a flame. Bodies containing pores, in which the particles are not close together, are called "*porous*" bodies, meaning bodies *full of pores* or holes.	I. Do the experiment with the cane; and show by applying a lighted match to another piece with no turpentine, that it is *not the cane* which burns, but the turpentine in the pores. Also put a lead-pencil, or a glass-rod, in turpentine, and try to burn these. They will not flame, because they have no holes in them to suck up the turpentine. Point out to class that these small holes are called *pores*; and refer them to small pores in their own *skin* (openings of sweat-ducts).
II. Other Porous Bodies— These include sponge, flannel, bread, loaf-sugar, dry earth, baked clay, lime, limestone, chalk, charcoal, blotting paper, etc.	II. Experiment with these, and note that each will hold a *liquid*. Why do we *wash* with sponge or flannel? (These hold water.) Dip a stick of chalk, or lump

NOTES OF LESSONS—POROUS BODIES—*Continued.*

Matter.	Method.
Some of these substances are *visibly* full of holes, or porous; as the sponge, which may be therefore taken as a *type* of porous bodies in general. Blotting paper depends for its use on this "porosity".	sugar, in red ink, and show that it becomes stained through. With blotting paper take up ink: use ordinary paper and we cannot do so. Contrast the action of blotting and ordinary paper, when pressed on wet writing.
III. Fibrous Substances— If a piece of *lamp-wick* be put into a vessel of water, and allowed to hang over the side, the end that was at first dry will soon become wet, and drain some of the water out of tumbler. All clothes, except waterproofs, are more or less porous; and *absorbent*, or *pervious* to moisture.	III. Dip a piece of *wick* into water, and let the children feel the other end. (It is wet.) How is this? (The wick is full of pores or passages between the fibres.) Refer to jackets, etc., holding water in a rain storm. When a lamp burns, the oil rises up along the passages between the threads, until it reaches the flame and is burnt.
IV. Candle— In a lighted *candle* the melted fat rises up the wick just as the oil did in the wick of the lamp. The flame melts the wax, or tallow, into a liquid; and this travels along the pores, and is burnt by the flame.	IV. Light a *candle*, and point out its basin of melted fat. Put out the candle, and cut off the wick, and show children, by pressing it out, that it is full of grease. With coloured wax the liquid may be *seen* rising at a distance.

120. RIVERS AND LAKES.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—During a rain-storm we notice on a road sloping from the centre to the sides :—

(1) That the rain-drops gradually run together, and at last form little streams.

(2) That these little streams run down the slopes on either side of the road, join others, and make larger streams.

(3) That at last the streams all unite, and form a still larger one in the gutter.

(4) That on the highest part of the road, the streams, which are few and very small, are turned aside, some running down one slope and some down the other.

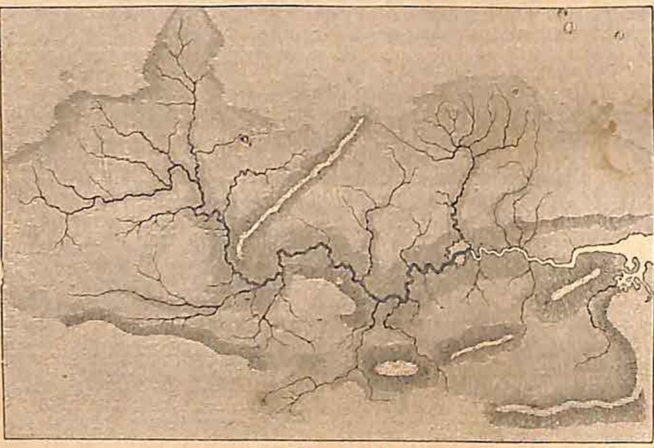
(5) That the streams are turned out of their way by every little stone or roughness in the road.

II. Application to Formation of a River.—What takes place on the **road**, takes place on a larger scale all over every **country** where rain falls.

(*a*) **Streams.**—Rain falls on the sloping ground. The drops run down the sides, join others, and at last form small **streams.**

(*b*) **Rivers.**—These streams run further down the slopes, and are joined by others, till at last a broader and larger one is formed, which we call a **river.**

(*c*) **Course of a River.**—As the highest part of the **road** turns aside the smaller streams, causing them to flow down either side, so the highest part of the surface of a **country** divides the larger streams referred to. This highest part is termed the **Water-parting.**



The Thames Valley.

Stones and **roughnesses** alter the course of the streams in the road, causing them to flow in various directions rather than in a straight line; streams and rivers are similarly turned out of their course by **mountains** and **hills.** These flow on till at last they enter the sea.

(*d*) **How Rivers are Fed.**—We thus see that rivers are kept supplied by **rain**; but when rain ceases, the supply is still kept up by **springs.** Some rivers have more water in summer than in winter: this is due to the melting of **snow** on the mountains.

III. Lakes.—(*a*) **Roadside Pools.**—The stream formed by the water running down the road is sometimes stopped, either by an accumulation of dirt and rubbish, or by running into a hole. In

both cases a **pool** is formed, which checks the course of the stream till the pool itself becomes full and overflows.

(*b*) **Application to formation of Lakes.**—(1) Streams flowing down mountain sides sometimes reach their lowest level, and are hemmed in on all sides by mountains, and so prevented from flowing away.

(2) Or the stream may flow into a broad and deep depression from which the water cannot escape till it overflows.

In each case a large pool or **lake** is formed.

121. WATER-SHEDS.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—We have already seen that of the rain falling on a road, or on the **roof** of a house, some runs down one side, some down the other.

II. Application.—(*a*) What we saw in the road is taking place on a larger scale all over the world. Rain falls upon sloping ground; some runs down one side, and some down the other. Streams are thus formed; and these unite to make rivers.

(*b*) To the ridge, down either side of which the river flows, we give the name **Water-shed**, or Water-parting, because it **sheds**, or parts, the streams.

III. Rocks forming the Water-sheds.—(*a*) In the case of the roof, we see that all the rain runs off, and forms the small streams in the spouting.

(*b*) The rain falling on sloping ground does **not** all run off into streams; some sinks into the ground.

(*c*) We also notice that more water thus disappears in one part of a water-shed than in another. This must be due to some difference in the nature of the rocks on which it falls.

(1) **Nature of Rocks.**—Those rocks through which the water readily soaks, or penetrates, have their particles lying loosely together, as in sand, gravel, etc., or their particles can be easily separated, as in the case of chalk and sandstone. Those through which the water does **not** readily soak have their particles packed closely together, or cannot be so easily separated, as in clay and granite.

(2) **Terms.**—The first of these we call **pervious** or permeable rocks; those through which water will not soak, **impervious**, or impermeable rocks.

122. RIVERS.

INTRODUCTORY SPECIMEN LESSON.

I. What a River is.—A river is a large stream of water flowing into another river, into the sea, into a lake, or, in some cases, it is lost in the sands of a desert, or flows underground and comes no more to the surface. Standing beside a river, we notice that it has banks; and these we call right and left, according as they lie to a person going down the stream. It also has a beginning or source; and an end, or mouth. The latter is so called because the banks open and part away from each other like the open mouth of an animal.

II. Sources.—Rivers very commonly begin in lakes; or in hilly or mountain districts, where the clouds drop their moisture in the form of rain, and the rain forms torrents, or soaks into the earth to come out again to the surface in springs.

At first, the source of the river is very small; and it seems to be of no importance. Beginning as a little silver thread of water, over which a boy could easily jump, it flows on and on, with windings and curves here and there, through pleasant meadows, by woody copses, by parks and gardens, by cottages and hamlets, over water-wheels and through mills, past lowlands and marshy plains, under railway and other bridges, through towns and cities, by wharves and workshops, under boats, barges, ships, and steamers, out and away to the ocean.

Wherever it has passed it has left a blessing behind it, watering the parched soil of summer, slaking the thirst of flocks and herds, filling canals, draining the ditches, bearing on its untired back the burdens of laden ships, and going on its useful way doing whatever good it can. It is covered with a forest of masts; ships of all sizes and shapes come here from all parts of the world, bringing their burdens of wheat, flour, silk, rice, tea, sugar, gold, silver, copper, tin, hemp, flax, marble, and other products.

Barges go up and down by night and by day, carrying timber, hay, straw, flour, wheat, coals, and other things useful to man; so that its cities may be daily fed, and its hands kept busy in the great human hives.

At first its waters are clear and sparkling, and some is taken out and stored up for drinking purposes for the use of towns. But, as men pour the filth of houses and workshops into it, and the tide flows up, the waters become fouler and duller, and at last salter and salter, as the tide washes into the mouth from the sea.

III. Feeders.—All the while the main river itself has been flowing, **Feeders**, or smaller streams, have been pouring their waters into it, swelling its size, and making it deeper, broader, and swifter.

123. SPRINGS AND WELLS.

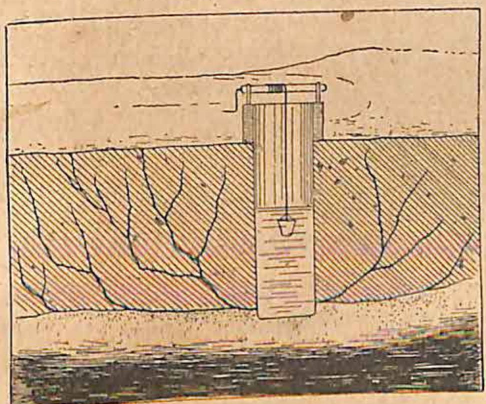
INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—Looking at the ground on which we tread we see :—

(*a*) That this land-surface consists mostly of a mixture of sand, clay, and mud.

(*b*) That besides this there are generally harder rocks below the loose soil, but sometimes coming above it.

(*c*) That these rocks, in the first case, either let rains soak through them or not, that is, they are either **pervious** or **impervious**.



II. Springs.—(*a*) Now I will draw a diagram, to show that the pervious or first kind of rocks lie in **layers** or beds, either level or sloping.

(*b*) Water sinking into the ground soaks through the surface, silt, gravel, and sand, but stops and collects on clay. It runs along between the layers of sand and clay, on the top of the latter, and, if this slopes, it continues to do so till the bed of clay comes to the surface at the side of a hill, when the water runs out of the earth there, and forms a **spring**.

(c) In other cases, the rain, after soaking through the permeable or pervious rocks, reaches an impervious one. It cannot soak through this, but trickles through the joints or cracks found in it, and so still travels downwards, till at last the impervious nature of the rock, and the absence of joints, prevent it going any lower. The water does not now remain still, but, by the force of the water coming down behind, it is pushed upwards through other joints in the same rocks, till it again reaches the surface and comes out again as a spring.

III. Wells.—These are deep shafts made through the earth till some **impervious** rock is reached. On some part of this rock the water collects. These shafts afford the water a place to collect in. It therefore flows into the **Well.** These shafts may cut through several layers of both pervious and impervious rocks, and in each case an outlet will be formed for the water lying on the impervious rocks to flow into the well.

The water does not disappear at the bottom; because the shaft has been sunk into an impervious rock, such as clay, so that the bottom and sides form, as it were, a basin to hold it.

124. SPRINGS AND ARTESIAN WELLS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Springs.—We must seek for the origin of **springs** in the coming again to the surface of that part of the rain and melted snows which has not been drained off from the surface in **freshets, brooks,** and **rivers.** Springs are thus the **underground rivers,** and also the sources of many of the **subaerial** streams of the earth.

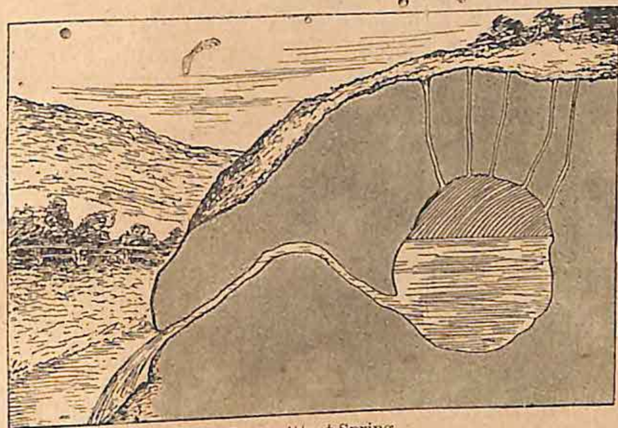
This rain-water first penetrates the **pervious** rocks of the surface —silt, sand, gravel, etc.—until it meets with an **impervious** rock, such as clay, upon which "water-bearing" layer ("stratum"), or in the fissures and rents of other rocks it accumulates, ever tending to lower levels and to outlets on the sides of mountains and valleys.

The **force** with which it comes again to the surface depends upon the **height** of the watery columns by which it is sustained; and hence springs may rise even from the bottom of the sea when they are forced up by watery columns on the cliffs near.

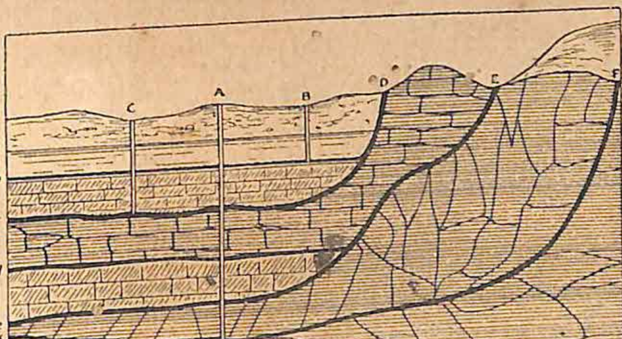
(a) **Surface-springs** rise from surface-beds of gravel, etc., and depend on **immediate** rainfall, so that they often dry up in summer.

(b) **Deep-seated** and **Perennial Springs** rise from greater depths than these.

(*c*) **Intermittent Springs** periodically flow and cease to flow, being dependant on expansion of gases, the rise and fall of tides, and the height of the water column in syphon-tubed and other mountain reservoirs and caves.



Intermittent Spring.



Artesian Wells.

II. Artesian Wells—Where Made.—These can be sunk only in districts where the rocks have been **bent** into a curve, concave toward the surface, having some of the beds of which they are composed **porous**, or **pervious to water**, along their line of "**out-crop**", or appearance at the surface.

III. How Explained.—The rain falls on the surface of the rocks at the sides of the valley ("outcrop"), descends the curve towards the bottom, being retained by impervious rocks beneath; and thus completely saturates the beds up to a certain water-level. When the overlying impervious beds are pierced by digging a well, and this water-level is touched, the water tends to rise in the well to the level above referred to. This may be above the surface of the country at the bottom of the valley, the liquid being forced up by the columns of water in the porous strata around the valley.

The principle upon which these wells depend is the constant tendency of fluids to seek their own level. The rain falling on the basin-shaped country, or on a plain surrounded by mountains of pervious rocks, soaks into the soil. It sinks until it is met by a "water-bearing" stratum, through which it can make no further descent. It must then follow the trend or inclination of this bed, being forced down by the weight of the column of water from the surface of the plain or mountain side at which it first entered the earth's crust. It cannot rise again to the surface of the earth at the lower level in the valley-shaped district, because of the overlying impervious beds.

125. SOLUTION AND SUSPENSION.

INTRODUCTORY SPECIMEN LESSON.

I. Meaning of Solubility.—(*a*) Action of Water on Salt.—(1) If I pour this water upon this salt, the grains of which the salt is formed are thereby loosened from each other and fall apart, and, as you notice, the salt gradually disappears out of sight.

(2) Now I put some salt into a glass of water, and not only do the grains fall apart, but the salt again gradually disappears. The solid salt has become a part of the liquid, or the salt has been "dissolved".

(*b*) Proof of Presence of the Salt in Water.—(1) Now I taste the water, and I find it tastes "salty", which shows that the salt is still in it, though I cannot see it.

(2) I next evaporate the water in the sun, or air; and the salt remains behind.

(3) I then boil the liquid till the water has all passed off as steam, and again the salt is left behind, as you see.

(4) Lastly, I treat sugar similarly, and get the same results.

II. Solution.—(1) The liquid which contains the dissolved solid is a "**solution**"; and the solids are said to be "**in solution**" when thus "**dissolved**" in the liquid.

III. Suspension.—(1) I put this gravel, sand, and mud into this water, and shake them up well; the water becomes discoloured, but after some time the solids are seen at the bottom of the glass in layers. Neither the gravel, sand, nor mud has been dissolved; but for a time the mud and sand are held up, or "**suspended**", in the water.

IV. Solution and Suspension Compared.—(*a*) **Solution.**—Solids are said to be **in solution** when they are dissolved in a liquid.

(*b*) **Suspension.**—Solids are **in suspension** when they are held up, or suspended, for a time between the particles of water.

V. Clearing.—I will now show you a solution which I for a time put by; you see that,

(*a*) A little while before it was simply muddy and "salty" water.

(*b*) Now the water is clear, with the **mud** at the bottom and the **salt** invisible.

VI. Cause of Change in Appearance.—(*a*) **Salt.**—(1) If the clear water be tasted, the salt is found to be still present.

(2) If I evaporate or boil a little of it, the solid salt is found at the bottom of the vessel. It was, therefore, dissolved, or held in solution by the water.

(*b*) **Mud.**—But the particles of mud were only separated and held up between the particles of water. The coarser and heavier a substance is, the sooner it will sink. The particles of mud being very fine were held a long time in suspension.

VII. Application to Rainwater, Springs, and Rivers. (*a*) **Rainwater**—(1) **Suspended Matters.**—In the air will be found particles of soot and dust floating about. The rain, in falling, washes out these impurities from the air, and holds them in suspension.

First Proof.—In this rainwater collected from a tank, a layer of mud has formed at the bottom.

Second Proof.—If I allow this rainwater to evaporate on clean paper, the soot and dust are left behind.

(2) **Dissolved Matters.**—When breathing we give off into the air a large quantity of foul air (carbonic acid gas); this is also given off by decaying animal and vegetable matters. The rain, in falling, cleanses the air of these impurities by dissolving them out of it.

(*b*) **Springs**—(1) **Suspended Matters.**—These consist of mud, sand, gravel, clay, iron, etc.

(2) **Dissolved Matters.**—These are various kinds of salts taken from, or dissolved out of, the rocks through which the spring has forced its way, such as chalk, lime, etc.

VIII. Removal of Matter by Rivers.—All this suspended and dissolved matter is carried down by rivers, and the former deposited at their mouths and in the sea; hence we find some river mouths choked with mud or sand. Thus the Rhine brings down each year enough lime to make 330,000 millions of oyster shells. The Thames carries down each year enough solid matter to make 14 solid cubes, each side measuring 100 feet.

IX. Saltness of the Sea.—Solid salt was left after the water had passed off as vapour. This vapour was nearly pure water, so if salt be continually added to water, and the boiling continued, still more salt will remain after evaporation.

X. Application to the Sea.—(*a*) **Rivers carry Salts.**—At one time our earth was gaseous, as the sun now is. This gradually cooled down, and formed the now solid earth and liquid sea. Some of the solids were salts, which were carried down by the rivers into the newly-formed seas, and were held there in solution.

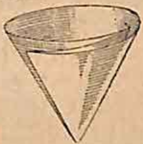
(*b*) **The Sea gets Salter.**—What took place with a glass of salt water takes place on a larger scale all over the world. The sun takes up the pure water from the oceans, etc., in the form of vapour, and leaves the solid salt behind. The place of this evaporated water is filled up by the rivers bringing in more water, with more salt in solution. This water is in turn evaporated and its salt left, and so the salt increases and makes the sea more salt.

126. NOTES OF LESSONS—SUSPENSION, SOLUTION AND FILTRATION.

Apparatus.—Water, tumblers, chalk, flour, blotting-paper, muslin, flower-pot, sponge, pebbles, sand, salt, tripod stand, Bunsen burner, rubber tube, evaporating dish, and piece of wire gauze.

Matter.	Method.
I. Suspension in Water— (*a*) When after rain we look at a brook, we notice that the water in it is very *dirty*. As the brook runs along, it washes small bits of soil, etc., into it, and carries them	I. (*a*) Take a glass of clear water, and powder some chalk, or put some dirt, into it. Stir it well and show class the *muddy* appearance. Ask what makes brooks, etc., dirty after rain. (The mud in them.)

NOTES OF LESSONS—SUSPENSION, SOLUTION AND FILTRATION—*Continued.*

Matter.	Method.
along with it. These are not very much heavier than the water, so they do not sink *at once*. (*b*) *Deltas* are thus formed from mud, etc., *suspended* in water, dropping down to the bottom (*vide infra*). (*c*) *Harbour-bars*, and bars at river mouths, are due to the same cause.	Why does not this sink at once? (It is lighter than pebbles, etc.) Ask for list of things suspended in a brook, river, etc. (*b*) Show a picture of a *delta*, and point out a delta on a map, and draw a diagram of one. (*c*) Show a picture of a *harbour-bar*, and draw a diagram of one in front of a river mouth.
II. Filtration— When rain falls, some of the water is *evaporated*, and some *sinks* into the ground. This last, after a time probably makes a "*spring*". The spring-water though flowing underground is quite nice and *clean*. The *sand*, the *gravel*, and the *rocks* of hills, etc., have kept back all the dirt, and acted as a *filter*. So the earth is a great filter. It acts like the fine *muslin* through which the housewife filters out the grounds of her coffee: or like the *flannel bag* used in straining blackberry jam, the materials of elderberry wine, etc. *Lakes* also act in the same way on a great scale. The muddy river coming into the lake at one end, drops down its sediment in the lake, and comes out at the other end comparatively *clear*, *e.g.* Rhine flowing through Lake Constance, and the Rhone through Lake Geneva in Switzerland.	II. Take some dirty water, and fold a piece of blotting paper into a funnel. Pour this water on the blotting-paper, and note that the water then becomes clearer. Show the blotting-paper, and note that the dirt, etc., has been *held back* on it. What has the blotting paper done? (Filtered the water.) Where do we get our drinking water from? (Taps.) Where does it come from into the taps. (Reservoirs.) Is this water clean or dirty? (Dirty.) It must be then *filtered*; but blotting-paper would not do to filter large quantities of it, so *gravel* and *sand*-beds are used instead. Explain the work done at the reservoir "Filtering Beds".  Make a filter with a flower-pot, sponge, pebbles and sand. Filter dirty water through this. Draw on the blackboard a diagram of a charcoal filter, and tell the class how this filter is used at home to make drinking water pure. Show that charcoal is "porous". Show on the map Lakes Geneva and Constance, and the Rhine and Rhone flowing through them.
III. Solution— (*a*) Sometimes we put things in water that "dissolve" or "melt". If salt or sugar be added to water, the water is still clear; but if *tasted* we know there is something present in the water. We cannot get the salt out of water by a filter, for wherever the water is, there also is the salt.	III. (*a*) Put a spoonful of salt into a glass of clear water. Is the water clear or thick? (Clear.) Why? (Because the salt has "melted", or *dissolved*.) How can we tell the salt is still in the water? (By tasting.) Note difference between *suspension* and *solution*. Filter salt water, and then taste it. (It is still salt.) Evaporate the water by boiling in a kettle,

NOTES OF LESSONS—SUSPENSION, SOLUTION AND FILTRATION—*Continued.*

Matter.	Method.
We must *evaporate* the water, to get the salt left behind. If too much salt be added to the water, some of it will not be dissolved; because the water is then "*saturated*" with the salt, and has as much of it as it will hold. We see the salt and sugar *visibly* dissolved from the lump into *smaller* portions. This is what further takes place with the smaller portions; until they become so small as to be *invisible* to the naked eye, and even to the eye aided by the microscope.	and then condense the vapour to a liquid in a cold cup, the latter is not salt now; the salt has been left behind in the kettle. Treat *sugar* in the same way; and note that the only way, as a rule, to remove dissolved matters is to evaporate; and if the water is required, to catch the vapour and condense it. Why will not all the salt dissolve? (Because water will hold only a certain quantity of salt.) Refer to bad drying days, when the air has become *saturated*, and will hold no more moisture in it.
(*b*) They must be *infinitely* small, as a few grains become scattered through such large quantities of water. There is no liquid which will dissolve so many substances as *water*. This is partly how it is that all the mountains of the world are slowly melting or dissolving away, in the rains, etc. A *solution* is therefore a *liquid* in which a *solid* has become dissolved: and may be *weak* or *strong* according to the quantity of solid taken into it. But when a certain quantity of the *solid* has been dissolved in a given quantity of water, the liquid will hold no more at that *temperature*. It is then said to be "*saturated*"; in the same way as the air is saturated when it is full of a *vapour*, and will hold no more of it.	(*b*) Compare this with a *building*, seen at a long distance; the bricks become invisible because of their small size. Ask for other *solutions* from the class, and for different *solids* and different *liquids* that will dissolve these. Ask children what is sometimes found at the bottom of a tea- or coffee-cup, when sugar is extravagantly used. (Sugar.) Remind the class that the word *saturated*, is like *satisfied*, and means *full*, having as much as one can hold, whether it be applied to a *child* and *food*; or to *water* and a *solid*; or to *air* and vapour or *moisture*.

127. THE FORMATION OF RIVER DELTAS.

SPECIAL INFORMATION FOR THE TEACHER.

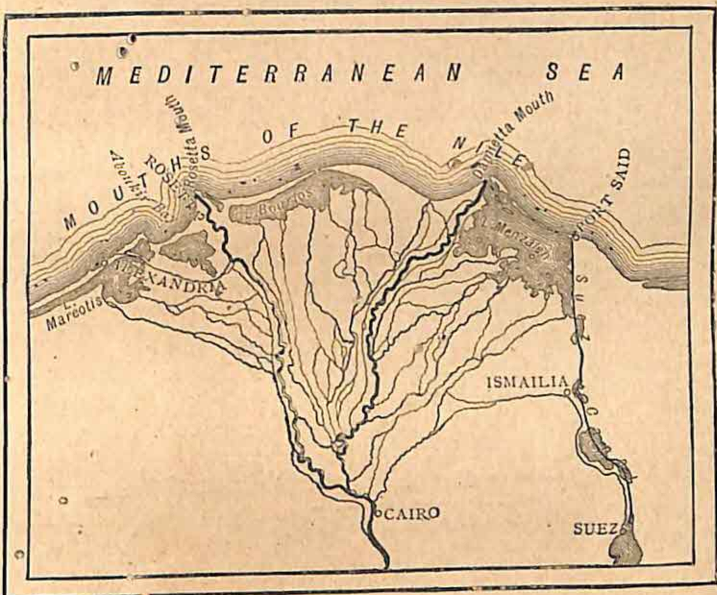
I. What a Delta is.—Deltas consist of alluvial soil brought down by rivers rising in elevated regions, which have worn down (or "eroded") by continuous action large portions of the surface soil through which their upper courses tend.

II. How formed.—The rapidity of the current is at first sufficient to carry along the detritus scooped out. As the middle and the lower river-valleys become successively more and more level,

the water-worn dèbris is laid down in the bed in the order of its density. At the mouth not enough force is left in the current to transport the alluvium still left. This, therefore, falls on the bed itself, raising it, and forcing the water to find new channels to reach the sea.

III. Deposits.—The deposits brought down and dropped in the delta are characterized by the remains of animal and vegetable life which are borne down by the floods from the higher valleys, and stored up in the delta.

If the river originally emptied itself into a gulf, as Herodotus relates of the ancient Nile, and as we know was the case with the Po and Ganges, not only does this gulf become silted up, but the



delta even pushes itself into the sea in a triangular form. The base of the land-delta is washed by the ocean, and the sides by the branches of the river; in the sea-delta all is covered by the water.

IV. Where found.—These delta formations occur not only on the fringes of the ocean, but also in lacustrine areas, on the margins of recipient and transmission lakes. They result in the latter cases in altering the site of the lake, making the water take

up a position lower and lower down the river valley as the lake fills up at one end, as seen in Lakes Constance and Geneva.

128. FORMATION OF DELTAS.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—(*a*) When we look at the rivers on a map, we see that some of them have each one wide mouth, and that others divide up into a number of streams or branches, and so enter the sea by many mouths.

(*b*) In the latter case the land appears to stretch out into the sea.

(*c*) By examining several rivers entering the sea in the latter manner, we see that the land at the various mouths is similar in shape to a fan spread out towards the sea. Because this land resembles the Greek letter "delta" (Δ) in shape, we give it the name "Delta".

II. Formation of Deltas.—(*a*) **Matter Suspended.**—In all river-water we find some suspended matter. This matter remains in suspension as long as the river flows rapidly.

(*b*) **Matter Deposited.**—(1) Just before the river reaches the sea, its bed is often less steep than before, and its speed is therefore also lessened. The suspended mud, clay, and sand, will now therefore be deposited, and form a sediment, as one was formed in a glass of water in a previous experiment. This sediment increases at the mouth of the river till it reaches the surface of the water.

(2) **During a flood** the river rises, and flows over this heaped-up mud, and deposits on it other suspended matters. When, therefore, the flood has gone down again, the new layer of sediment is found to be above the surface.

III. Shape.—**We gather from this**:—(*a*) That these deposits are **filling up** the mouth of the river, and are gradually stretching further out to sea.

(*b*) That the sea once filled the place now filled by the delta, so that towns once on the coast are now **inland**, as at the former mouth of the River Po.

(*c*) The strange **fan-like** shape is therefore due to the deposit being first made between the banks of the river; and as the water was carried out to sea, the deposit spread over a greater surface of the bottom of the sea. The rivers still find a means of entering the sea by washing away the deposit, and forming channels through it.

(*d*) Land formed at the mouth of a river by deposited matter is termed a **delta**.

(*e*) Deltas cannot be formed where the river enters the sea by a rapid current, or where the mouth of the river is well scoured by the ebb and flow of the tide, as in an estuary.

(*f*) Banks of sand and mud are sometimes formed further out at sea through the dropping down of suspended matter.

IV. Channels become silted up.—With some rivers even the mouths themselves would be choked up with mud, but for the use of a dredge or large scoop. Dredging is generally done when the tide is running out, to allow the mud to be carried out to sea. The navigation here is so difficult, that men who know the channels well are obliged to be employed to navigate ships, and so prevent accidents by running on the mud or sand banks, which are also continually changing their position.

129. THE WORK DONE BY RIVERS.

INTRODUCTORY SPECIMEN LESSON.

I. The Cradles of the Human Race.—As man depends for his existence on animal and vegetable foods, and as animals depend for theirs directly or indirectly on plants, the cradles of the human race are the great river valleys. These are filled with the fruitful soil washed down by rivers, where corn, rice, etc., can be cultivated. Here, therefore, are the ancient seats of civilization in the valleys of the Nile, Ganges, Indus, Hoang-Ho, Yangtse Kiang, etc., and, in the New World, the valley of the Mississippi.

There are exceptions to this:—

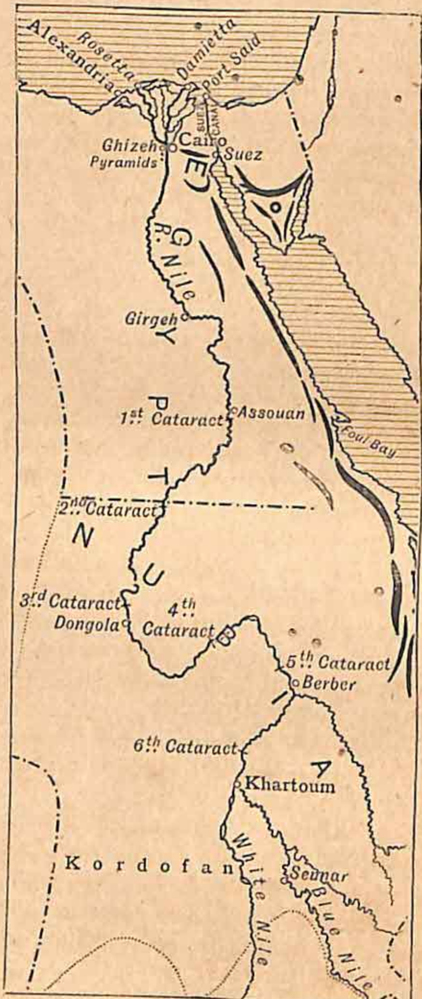
In modern coast towns where commerce (or, in the manufacturing towns, where trade) takes the place of agriculture, and where the workers are fed by the agricultural produce of other lands brought to them by transport.

II. The Nile and Egypt.—The best example of this is seen in Egypt, which Herodotus called "A gift of the Nile", and which is a fruitful garden in the midst of a desert, solely because of the mud and water brought down to it by the Nile. Another, but smaller, instance is that of the Po, and the fruitful Plain of Lombardy: a larger example is that of the valley of the Ganges. In all three cases the river beds were once gulfs.

III. Filling up of Lakes and Seas.—But whilst rivers thus bring down alluvium to build up fertile plains, they also fill up lakes and seas.

A good instance of the latter has been just referred to in the

Po. This river formerly flowed into an arm of the Adriatic Sea; but the gulf has been filled up with alluvial soil, and what once was a sea is now the Plain of Lombardy. The river is also still extending this plain across the head of the Adriatic Sea, which will probably in time be thus filled up with this delta.



Sketch Map of the Nile.

The same thing is seen on a larger scale in the Nile, which is filling up the eastern half of the Mediterranean Sea. Thus rivers convert seas into large continental areas, just as they wash down continental areas into the sea, until in time the sites of the continents become the sites of oceans.

On a smaller scale we see this same work done under our eyes in lakes. The Italian lakes, Maggiore, etc., are being filled up with the mud or alluvium brought down by rivers from the Alps. Lake Maggiore is being thus filled up with the river deltas of three rivers at once, and in time will be a plain instead of a deep ice-carved gorge filled in by running water.

The same work of rivers is seen on a still larger scale in the New World, where the Missouri, Amazon, etc., are eating away the "flesh" from the "bones" of the continents of North and South America.

IV. Rate of Progress.—We see that there is a law which regulates the rate of progress of this work done by rivers. The

higher the source of the river the greater the **velocity**; the greater the **velocity** the more rapidly is the work done: and therefore high and large mountains give swift and large rivers; and large, swift rivers give large resulting sheets of alluvium.

This explains the origin of the northern plain of **India** laid down by the **Ganges,** where once the Bay of Bengal flowed up to the feet of the Himalaya Mountains. And in like manner it explains the origin of most alluvial river valleys, and the reason why they are, or have been, the seats of crowded civilizations.

130. VALLEYS.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—We saw in a previous lesson that the streams run down a road during a rainstorm; and,

(1) That each makes a little passage or channel for itself.

(2) That as the streams increase, the channels widen and deepen.

II. Application to Formation of Valleys.—(*a*) **Materials of Earth's Surface.**—The part of the earth on which trees and plants grow is formed of a mixture of mud, clay, and sand. Below this we have rocks of granite, sandstone, chalk, etc.

(*b*) **Washing away of Upper Surface.**—During the rainstorm little channels were formed on the road by the washing away of the soil by the little streams. The same thing happens all over a country. Streams are formed which rush along with such force that they wash away this soft upper soil, make a broad channel, and lay bare the rocks beneath.

(*c*) **Removal of Rocks.**—It would be difficult to remove these rocks if it were not for the further action of the air, rain, frost, floods, and glaciers.

(1) **Air.**—The stones of an old building, tombstones, the rocks of a mountain side, etc., crumble away. We say this is due to the action of the **weather**; in reality it is due to the oxygen and carbonic acid of the air eating them away. We have the same kind of work done in the rusting of iron from the oxygen of the air eating into the metal.

(2) **Rain and Frost.**—Rocks have cracks or "joints", in them; they also lie in beds (strata) or layers, often with mud, sand, etc., between the separate thin layers. Into these the rain runs, washing away the looser rock, and so widening them. This water freezes in winter, and as ice takes up more room than water, so in this

freezing the joints are forced further apart, till the face of the joints crumble, and the spaces between the beddings are widened. We also see this expansion in pipes bursting during a frost.

(3) **Floods.**—During heavy rains the water flows down the valley, and washes away the broken masses of rock, and so makes the channels in the rocks wider. The masses of rock, as they are hurled along by the torrent, crash against other rocks, portions break off, and so again the channels widen and deepen till a broad valley is formed.

(4) **Glaciers** also grind against and wear down the same rocks, and so help to make wide and deep valleys.

III. River-bed.—By this washing away of the loose upper soil, and by the removal of rocks, the channels are made sufficiently deep to hold the water which enters them, and thus a constant stream of water is found in them. We call this channel the **river-bed.** A river-bed is not straight, because water will always find its lowest level; and will therefore flow round an obstacle, such as a mountain, and wash away the soil of which it consists.

131. GRAVEL, SAND, AND MUD.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—On looking at the coast of England we see;

(1) That some parts of it are high, as at Scarborough, Shakspeare's Cliff, near Dover, etc., and others low, as at Cleethorpes, Skegness, etc.

(2) That the higher parts form **cliffs.**

(3) That the sea-shore is formed in the low places of sand or mud, and in the higher parts of harder rocks, granite, limestone, chalk, boulders, etc.

II. Wearing away of Cliffs and Rocks.—From this picture in front of the class of a pebbly beach, we see, that as we leave the sea going up from low-water mark to the base of the cliff, the stones become larger, until we reach the foot of the cliff, where they are rough masses of rock broken off from the cliff itself.

(*a*) **Wearing away of Rocks by Rain.**—In a previous lesson dealing with rain-water we learned that it washes from the air quantities of carbonic acid, made by decaying vegetable and animal matters, etc. Rain-water with carbonic acid in it dissolves some rocks, and carries away the dissolved part in solution. It gets into the cracks or joints, and washes away the softer parts, till the cliff becomes undermined, and falls.

(*b*) **Wearing away of Rocks by Frost.**—The water in the joints also freezes and expands, and thereby thrusts the rocks apart, and so causes them to fall, as it bursts water-pipes during a frost.

III. Formation of Gravel, Sand and Mud.—From this picture of the action of the sea, we see,

(1) That at the foot of the cliff we have broken rocks with rough, uneven surfaces and sharp edges.

(2) That going down to the water, these gradually give place to smaller pieces of rock, with their edges rubbed down, and their surfaces smoothed.

(3) That still nearer the water we next find smooth, rounded stones.

(4) That closer to the sea these gradually give place to smaller ones, till at last we find sand.

(*b*) This sand under a microscope is seen to consist of minute particles of stone, like the larger stones and rocks found near it.

(*c*) The whole of the sea-shore is therefore covered with fragments of the cliff, varying in size and appearance from the great angular masses at the foot to the finest particles of sand near the low-water mark.

IV. Causes of the Changes.—(*a*) **Gravel.**—In storms great waves dash against the larger masses of rocks at the cliff foot, and wear them away into smaller pieces. These are rubbed against each other, ground and pounded, till all their rough edges are rubbed off, and they become smooth and round, and are called gravel.

(*b*) **Sand.**—These small rounded stones, and the angular pieces chipped off from them, are still further ground down and rubbed against each other by the waves till they become grains of sand.

(*c*) **Mud.**—These grains are still further worn down to very fine powder, and with these there is generally a mixture of clay, the whole forming "mud".

132. CHALK.*

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—Chalk largely consists of the "tests" of microscopic foraminiferae, secreted by minute organisms from the carbonate of lime of the ocean, as similar beds are being now formed in the "ooze" of the Atlantic.

The great geological formation known as the White Chalk, stretching over the south coast of England, and over large por-

* *Vide supra*, p. 67

tions of Europe, is "almost wholly composed of the shells of foraminiferae, visible only under the microscope". The smallest fragments contain an immense number of these "shells"; and Paris may be said to be built almost entirely out of them.

II. How formed.—Chalk is found in beds, and is due to a mechanical, chemical, and organic origin. It is a marine deposit, precipitated in seas thronged with oceanic life. Into this flowed rivers from countries of a temperate or sub-tropical climate, as is proved by the vegetable drift occasionally found in the chalk, as well as by the corals in it. The seas in which the deposits took place in England were open to the north, as coal and granite have been found embedded in the chalk, as if borne thither by icebergs, which occasionally reach comparatively warm latitudes.

III. Composition.—Chalk consists of foraminiferous shells and fossil sponges, and this points to an abundance of the forms of life at the time of its deposit. There was a large quantity of silica present in the waters of deposit, as is proved by the flints so largely met with in some of the beds. The chalk of the lower beds in England is generally without flints, and is somewhat impure, and this points to estuaries with banks of clay in the neighbourhood of the deposits into which rivers bore down detritus from the land. Over this are the chalks of the upper beds, very pure, and interspersed with flints, either separate (in nodules), or in thin bands of great width and length.

133. LIMESTONES.

SPECIAL INFORMATION FOR THE TEACHER.

I. What they are.—Marine limestones are mainly the accumulated deposits of the calcareous "tests" of minute organisms (foraminiferae, etc.), which have secreted the carbonate of lime from the waters of the ocean. These limestones are not the result of chemical precipitation of the carbonate of lime in the water, since the amount of carbonic acid present is sufficient to keep in the fluid state five times as much carbonate of lime as exists in the waters of the ocean.

II. Present Formation.—The very same process of limestone formation is going on at the present day in the deposition of the ooze of the Atlantic, which is brought up by deep-sea soundings. The microscope shows that many of the foraminiferae there met with are identical with those of past geological times. As much as

95 per cent. of this ooze thus consists of the "shells" of these animals. The marvellous abundance of life accounts for the great thickness of the beds; thus in one ounce of sand gathered from the Caribbean Sea, four million foraminiferae have been found.

These minute tests have been found in great abundance in dredging and sounding even at a depth of three miles; especially where warm currents abound.

In the West Indies large deposits of limestone are being still laid down in basins, or lagoons, almost surrounded by coral reefs. Here a soft calcareous mud is being formed from corallines, molluscs, crustacea, etc. When dried, this mud is very like common chalk, and by a moderate pressure might be made to resemble it still more closely.

III. Underground Limestone Caverns and Water-courses.—These are due to the influence of subterranean movements rending and fissuring the hard limestone formations, and to the eroding and solvent action of water in springs and subterranean streams, assisted by the joints and divisional planes by which limestones are frequently intersected. These caverns are not confined to the more recent limestones of the carboniferous formation, though they are met with most abundantly there; but may be seen also in other limestones.

The varying characters of the caverns and underground water-courses lead up to an explanation of their mode of formation. Some are cracks and fissures, narrow but prolonged, penetrating far into the hard rock, and coming out to the surface at one end. These are probably due to subterranean forces rending the rigid crust above.

In others, the caverns consist of a series of extensions connected together by passages, and all of a nearly equal height and direction, with abysses hundreds of feet deep. These often contain lakes and streams of water; and the presence of these sheets of water, taken in connection with the soluble nature of the rock, gives the clue to the origin of these caves as due to carbonic acid.

IV. Carbonic Acid.—Of all mineral ingredients, lime combined with carbonic acid is the most abundant in streams percolating through the soil, and issuing to the surface from underground water-courses and caverns in limestone districts. The sufficiency of these streams to perform the eroding and solvent actions ascribed to them, may be measured by the enormous quantities of calcareous matter they deposit, when they come to the atmosphere and lose there a portion of their carbonic acid.

134. LIMESTONES.

INTRODUCTORY SPECIMEN LESSON.

I. A Sedimentary Rock.—Limestones make up one of the three great divisions of sedimentary rocks (*vide infra*), viz. :—

(1) Limestones; (2) Clays; and (3) Sandstones; laid down in lakes and seas.

With these are included chalk, built up of "shells" of once living creatures, and marble, which is limestone that has been very much altered.

Limestones are found in very many parts of the world; and sometimes they are hundreds of feet in thickness, as in Derbyshire, in our own country.

II. How formed.—If we visit a limestone quarry, or a museum that contains fossils from a limestone district, we see that the limestone frequently has embedded in it fossil shells: it is a sort of graveyard in which the remains of old forms of life once living in the waters of seas and lakes now lie buried. It also very often has in it the bones of land animals of a very ancient date, and of a very large size.

We can understand where the shells came from, by noticing the great heaps of shells often found on the sea-shore at the present day, washed up by waves, and a little while ago having living sea-animals, or "shell-fish" in them, such as cockles, whelks, etc. We also find on the same sea-shore such creatures as living and dead star-fishes.

In the same way, in days long gone by, when the sea or lake existed where now the limestone quarry is, there were in the waters shells, and animals somewhat like star-fishes, besides sponges and other living creatures. After these animals died their shells, etc., became covered over and cemented together with fine mud, until they were often as thick together as plums in a pudding; and now we see them preserved in the limestone. Sometimes a slab of Derbyshire limestone is so full of these that it looks nearly all fossils.

Just in the same way limestone rocks are being laid down at the bottom of the deepest parts of the oceans at the present time. This is the case at the bottom of the Atlantic, between Ireland and N. America, where the Atlantic cable stretches out like a huge dead sea-serpent in this ooze.

Sometimes the thickness of these deep-sea limestone beds increases, or they "grow", at the rate of as much as a foot in a hundred years.

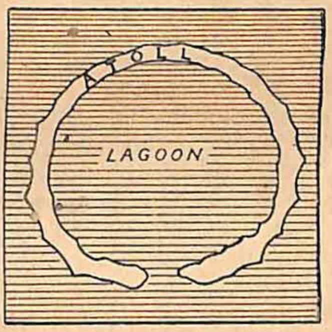
135. CORAL REEFS.

SPECIAL INFORMATION FOR THE TEACHER.

I. **How formed.**—The origin and formation of the atolls and barrier reefs of the Pacific are due to the combined labours of polyps which require an average winter temperature of the sea of not less than 66° F. The head-quarters of these coral-builders are on the islands and shore-lines of the tropical and subtropical portions of the Pacific Ocean, where they form masses often many miles in length.

II. **Atolls and Barriers.**—The origin of both atolls and barrier reefs is the same; the formation is different.

(*a*) Atolls are reefs more or less circular, enclosing a central lagoon connected with the outside ocean waters by breaks in the reefs.



(*b*) Barrier reefs resemble these in enclosing sheets of water; but have an island in the lagoon, between which and the circular reef a deep channel intervenes. An example of the barrier reef is that of Australia, 1200 miles long, 30 miles broad, and having an area of 33,000 square miles.

III. **Coral.**—In the comparatively shallow Pacific Ocean we find coral being formed. Coral is also made up of limestone; but it is not dropped down to the bottom of the sea like other sedimentary rocks, but is the skeleton, on which coral animals once lived. It is the lime-skeleton of these, just as sponge is the horny, or flinty skeleton of other jelly-like sea animals.

Each piece of coral contains the lime-cups in which the little creatures once lived that made it; and the whole is made out of the salts of lime held in solution in the sea-water, and which the builder got out and turned into coral.

Coral is secreted from the ocean waters as carbonate of lime in the tissues of the maker, so as to form a continuous corallum.

The red coral is secreted by the outer layer of the polyp. The creature is limited to depths of from 18-20 fathoms, perpetually covered by the tide. The most common corals at moderate depths are the madrepores, astreas, porites, and millipores.

A coral reef is a really more or less compact limestone barrier mingled with sand, shells, sponges, sea-urchins, etc., with a weathered and often verdant surface.

In those waters where atolls and barrier reefs abound, as in the Pacific Ocean, Mr. Darwin has shown that there is a continuous subsidence of the mountain flank upon which they are constructed. But there are also within the same oceanic area many instances of considerable districts where the opposite change of level has been, and is still, taking place; and where the coral has been upheaved above the level of the surrounding waters.

136. COAL.*

INTRODUCTORY SPECIMEN LESSON.

I. Forests, Peat and Coal.—Besides coral made by living animals, we have also coal; but this is made from once living plants, not animals. So, like coral, it is an organic rock, or one that has been made by organisms out of organic, or once living materials. It is in this way different from sedimentary, as well as from igneous rocks (*vide infra*).

Stagnant pools, marshes, etc., soon become over-run with weeds and vegetable matter, especially in hot countries where plants grow very rapidly. Among these there will be mosses, ferns, fern trees, and even thickets and bushes of flowering plants.

If we dig down into the ground where these grow at the present day, we often find for many feet nothing but vegetable matter—roots, stems, leaves, etc.,—that has not rotted away, but has been preserved, but very much changed. This gives us peat, as in the peat-bogs in Ireland. The deeper we go down, the more changed is the vegetable matter from what it is at the top. This vegetable matter is what coal is made of.

II. Coal.—But coal is found not only in beds, but in layers. Some of it is hard and shining; other parts of it are more like charcoal, and are soft and dull, but still black.

III. A Coal Mine.—If we examine the mineral refuse brought out of a coal-pit and thrown away, we see that it is mostly shale,

* *Vide supra*, p. 61

or hard-pressed black or black-grey clay. But this often has in it marks of ferns, shells, tree-trunks, etc.

Going down to the coal-seam, we come to shale on the top of it, then coal, then shale, or clay, again underneath the seam. We notice that the seams are not very thick; but they extend a long way.

Sand may be deposited from either fresh or salt water; either brought down by a river, or washed up by the sea. But as we find fossil leaves, tree-stems, trunks, etc., in the sand found over a coal-seam, this sand must in most cases have been brought down by a river. Then we also get clay beneath: this deposit also reminds us of the mouth of a river, or of a broad shallow lake, as we find clay or mud is being also laid down by running water at the present time.

In the clay under the coal-seam, we often find the roots of trees: therefore, the water in which this clay was dropped as mud, must have been shallow, as in a marsh or pool, or low-lying land with rivers near flowing into it from some neighbouring mountain or hill, and with forests and marshes near it.

After the deposit the ground sank, and with it the vegetable growths on it; and the river washed sand and mud over these. Later the land rose again, and more plants again grew on the same spot, and so, time after time, the plants grew, and the mud covered them up, until we get now many seams of coal there.

137. ORIGIN OF COAL.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Under-clay.**—From the under-clay beneath most coal beds, it has been inferred that it has underlain all the coal, but has been since denuded off those layers where it is not at present found; but this is an inaccurate generalization.

II. **Forest-submergence.**—It has also given rise to the theory of submergence of forests as the origin of coal, because of the innumerable stems of fossil plants with their rootlets and fibres which it largely contains. It is supposed that the fine materials of the underclay constituted the soil of a vast plain, or savannah, in which we now find the fossilized roots of gigantic trees; the whole having been inundated from marine or lacustrine irruptions, or by a subsidence of the site of the ancient forest.

It is thus maintained that these beds of under-clay were at one time vast plains and savannahs, on which gigantic plants flourished; while the coal itself is derived from the carbonized product of the stems and leaves. These plains are supposed to have been then suddenly inundated by freshets and floods, or by irruptions of the sea; subsidence after subsidence—each followed by successive elevations—having occurred to produce the seams of coal.

III. Coal Plants.—It is now known that the coal plants consisted much more of mosses, ferns, and other lowly flowerless plants, than of plants of larger growth and higher range of development.

In ordinary schools the subject of "Phenomena of the Earth and Atmosphere" will terminate at this point in Standard III., and be continued in an advanced direction in Standard IV. In large schools, liberally staffed, the upper section of Standard III. in some cases will be strong enough to take up in Standard IV. the continuation of this subject remitted to Standard IV.

PART IV.

STANDARD IV.

Government Requirements.—"*A more advanced knowledge of special groups of common objects, such as:—*

(*a*) *Animals, or plants, with particular reference to agriculture, or*

(*b*) *Substances employed in arts and manufactures; or*

(*c*) *Some simple kinds of physical and mechanical appliances,* e.g. *the thermometer, barometer, lever, pulley, wheel and axle, spirit level.*"

Revised Code.—Schedule II. *Class Subjects. Art.* 101 (*e*).

"*Course I. Science of Common Things in reference to the laws of health and the conduct of life. Simple mechanical laws in their application to common life and industries.*

Pressure of liquids and gases."

Supplement to Schedule II. *Alternative courses. Elementary Science. Revised Code.*

Part IV. provides the teacher, it is hoped, with ample materials for the requirements enumerated above in departments (*a*), (*c*), and Course I.

For economy of space, the teacher is referred for the items included in (*b*), to Hassell's "Common Things", "Familiar Objects", and "Technology for Schools", by the same publishers; as these text books admirably cater for this part of the syllabus.

(*a*) The **Vertebrates** in their common characteristics; and the principal **Orders** in their special features, having been dealt with in Part III., the principal **Classes** of the Invertebrates are now taken in hand in Part IV.

But it has to be borne in mind that we are merely providing material for teaching "Elementary Science as a **Class** Subject", not for a Specific Subject; for elementary information on Animals and Plants, not for the complete sciences of Zoology and Botany. The treatment here given therefore is broad and general, and suited to boys of such young age as Standard IV. Accordingly the lowest forms of animal life are only very briefly discussed, and the space is reserved for the more important Insects, Arachnida, and Crustacea.

No provision is made for the item, "with particular reference to agriculture", as, in the case of town schools, this would needlessly

take up valuable space. In country schools taking up Elementary Science as a Class Subject, the teacher can supplement the instruction here given by the Rev. Theodore Wood's "Elementary Science Readers", Standards IV., V., and VI., by the same publishers.

In the Botany, again, only a few of the principal Orders have been taken, for similar reasons to those just stated.

(*c*) Special note is to be taken of the word "appliances" in this department of the Syllabus. The principles and laws of the "simple mechanical powers" are reserved by the Government, and by the author, for Standard VI., as their enunciation would not be intelligible to younger children. But the commoner applications of these principles to instruments in everyday use, and which are generally so interesting to boys, and can be concretely represented in school by the instruments themselves and by models and diagrams, have been dealt with instead.

In addition to (*a*) and (*c*) the lessons on Natural Phenomena of Parts I.-III. have been continued in Part IV.

It is hoped that this mode of treatment will provide ample materials for a course of Elementary Science, to be drawn up by the teacher himself, that will be at once interesting, suited to the limited average age of the class, and not too ambitious in its scope. It has been practically found successful in a large group of Board Schools in England, where the children have without exception been delighted with the provision thus made to teach them to observe and think, as well as to remember.

THE ANIMAL KINGDOM: INVERTEBRATES.

JOINTED ANIMALS WITH SIX LEGS.

138. INSECTS.

SPECIAL INFORMATION FOR THE TEACHER.*

(FIRST SKETCH.)

I. Introduction.—The animals previously taken in Parts II., III., have an inside framework of bones—the backbone being a marked feature of the Vertebrates.

*At this stage the teacher will be able to draw up from the "Special Information" his own "Notes of Lessons", in those simpler cases in which they have been here purposely omitted.

We now deal with Insects, which have no bones. These are called insects, because the body appears to be cut into parts. We can divide each specimen into three parts: and gum these on a card with the undivided specimens below, and thence see the application of the name "insect" as meaning cut into.

II. External Skeleton.—This is made up of thirteen "rings" or "segments", seen most plainly in the caterpillar stage. Each ring consists of two half-rings joined together by a strong elastic skin which allows of expansion for breathing, etc. The skin of the segments is hard and firm. As a train is made up of carriages coupled together by chains allowing the whole train to bend; so the segments of the insect are joined by an elastic skin, which acts like the coupling chains, in order that the insect may swell out, and lengthen itself. We can see all these points in specimens; and show by folding paper how the rings are made of folds of skin, and the use of the rings in bending the body. To assist this the skin is generally soft, and there are no bones. Those insects that burrow have hard skins, as may be seen in a beetle.

III. Breathing Apparatus.—Mammals, Birds, and Reptiles breathe by means of lungs, and Fishes by gills; an Insect has neither of these organs. But instead there are round, or oval openings on each side of the last nine segments. These admit air into a tube running the whole length of the body, and sending off branches like the arteries and veins in our bodies. These again subdivide until every part of the body is supplied with small breathing tubes, even to the tips of the claws. These tubes are kept open when the insect turns and bends, as an india-rubber tube is prevented from collapsing by inserting a spiral spring in it. We preserve eggs by exclusion of air, by grease or lard. If insects were thus served the openings of these air-tubes would be blocked, and the insects would die for want of air. We thus see that the mouth is not used for breathing, as with Mammals, etc., and the reason why.

IV. Eyes.—All the Backboned Animals have two eyes; a butterfly and a bee seem also to have only two eyes; but really each "eye" is made up of very many, in some cases as many as twenty thousand. But still with so many eyes, they yet see only one object, as we also do with our two eyes. The eyes are always in the head in Insects, as are also the feelers and mouth: we can see this in a picture of the butterfly, cockroach, etc.

V. Appendages.—(1) Attached to Head.—(*a*) Feelers. These are one on each side of the head, of various shapes and sizes in

different insects. They are variously supposed to be organs of feeling, smell, and hearing. Insects must possess some sense of smell, since they fly to their food even against the wind, the wind in this case carrying the smell to them.

(*b*) **Mouth.** The mouth also varies in shape, according to the **food.** If the food require tearing, the **jaws** are strong, curved, and in some cases armed with "teeth". These jaws move from side to side (laterally), not up and down (vertically). If the food be flower-juices, then the insect has a **trunk,** or a long narrow tube, which can either be straightened out to suck up the juices from the flower or packed away beneath the head, when not required.

Some have no mouths, and consequently do not live long; the May-fly lives only one day. We can easily see the short sucker of the house-fly, and perceive the absence of it in beetles.

(2) **Attached to Chest.**—(*a*) **Wings.** These consist of 0, 1, or 2 pairs. The common house-fly and daddy-long-legs seem to have only one pair of wings; but a closer look shows us in addition two **knobs,** one on each side, where the hind wings generally are. If one of these "balancers" be cut off, the insect cannot fly, since these knobs are required to **balance** it.

In the beetle, the front wings are hard, and not used for flight, but to protect the other two, as the owners burrow underground for food.

The wings on Insects are always attached to the chest, as may be seen in the butterfly, moth, and beetle. There is a single pair in the house-fly. If we lift up the upper horny pair in a beetle we see the under transparent pair: the former are called "wing-covers".

(*b*) **Legs.** These are six in number, and are present on all insects; but sometimes only four are plainly seen. We see from specimens that the legs are attached to the chest.

VI. Development.—Insects pass through three stages before reaching their perfect state from the **Egg**:—(*a*) **Larva,** caterpillar, maggot, or grub; (*b*) **Chrysalis, Pupa,** or "**Baby**"; leading up to (*c*) The **Perfect Insect.** We can readily see how unlike the caterpillar, chrysalis, and butterfly are to each other in appearance, colour, size, etc.

The **Egg.** The egg of an insect has just the same parts as in the hen's; but differs in size and shape.

(*a*) **Grub.** The hatched insect soon begins to eat food; and it is always so placed as to find its food near at hand as soon as it leaves the shell, since in many cases the mother is already dead. As soon

as hatched it commences to eat, and whilst a grub goes on eating almost without stopping.

So much eating makes the grub **grow** fast. The skin at last will not stretch further; it does not then grow, but splits open down the back. We may compare this with a boy's coat splitting in the same way. The grub frequently eats this old skin, and fills out its new skin. This change of skin goes on five or six times before the grub is full grown. At last the grub can eat no longer, and hides itself under the bark of a tree, or the ground, or a leaf. It looks as if dead; but the skin splits again for the last time, and then the creature is no longer a grub.

(*b*) **Chrysalis, Pupa,** or **Baby.** This is called a baby because the limbs are packed away under an outer skin just as a baby's are in swaddling clothes. There is no eating nor moving now, as a rule; but the "perfect insect" is being formed under the hard skin. When this is fully formed, the outer covering splits for the last time, and the creature comes out as the perfect insect.

(*c*) **The Perfect Insect.** At first the wings and legs are weak, but the air soon hardens them, and in half an hour the insect is often able to fly. It now grows no more; but flies abroad from flower to flower, if it is one that lives on nectar. The perfect insect differs from the caterpillar in the following particulars:—

(1) It generally has **wings.**

(2) Instead of **biting** jaws it often has a **sucker.**

(3) It has left off its four pairs of **stump-legs.**

(4) It has three new pairs of longer **chest-legs.**

VII. Kinds of Insects.—Some insects are **useful** to man; others **injurious.**

(*a*) **Useful** Insects.—The **bee** is useful for honey, and for making flowers able to grow perfect seeds: the **silkworm** for silk, and the **cochineal** for making a red dye.

(*b*) **Injurious** Insects.—These include **gnats**, that sting; **gadflies**, that burrow in the skins of cattle to lay their eggs there; **moths**, that destroy clothes. Others, as the turnip-fly, eat up leaves of plants or of trees, or consume "fruits" and grain. Some devour roots of grasses; other, as **locusts**, eat up everything that is of a vegetable nature. Some bore the timber of trees, as the ant in hot climates; while mosquitoes sting us.

(*c*) **Preventers** of these injuries.—In their turn insects are eaten by birds, frogs, moles, and by other insects.

VIII. Examples.—To illustrate these **Kinds of Insects**, we can gum on a card at least one specimen of each of the following:—

Beetle, grasshopper, cockroach, cricket, dragon-fly, bee, wasp, ant, butterfly, and moth; and let each Order of insect occupy a separate line; thus, beetle, top line; grasshopper, cockroach, cricket, the second line; dragon-fly, the third; bee, wasp, ant, the fourth, etc. Referring to these specimens, we see that each is easily divisible into three parts; yet all are different, and we can find out for ourselves the differences, and refer these to the habits of the owners, and specially to their **food**, and their means of obtaining it.

(*a*) Thus the **beetle** has a hard skin, horny wings, heavy body, limbs of great thickness, no sucker, with the underwings folded because they are longer than the upper ones. Hence beetles burrow, do not fly much, but crawl along, and live on roots and leaves.

(*b*) The **grasshopper** has long, thick hind legs, wing-cases, and no sucker; so it moves by leaping, and eats leaves and roots.

(*c*) The **dragon-fly** has a long, thin body, two pairs of very long wings (lace-like in structure), large eyes and jaws, and no wing-covers. Hence it flies very rapidly, eats insects, and never burrows.

(*d*) **Bees, wasps, and ants** live together in numbers, make cells, and store up food for winter.

(*e*) **Butterflies and moths** have broad wings, slight bodies, long, curled-up suckers; so live much on the wing, and suck up nectar.

139. INSECTS.

SPECIAL INFORMATION FOR THE TEACHER.

(SECOND SKETCH.)

I. General Characteristics.—All insects have:—

(1) A **Head**, with eyes, feelers, organs of taste, and biting or sucking organs.

(2) A **Chest** (thorax) with legs (and wings, if present at all).

(3) A **Belly** (abdomen) containing digestive organs, and giving attachment to neither wings nor legs.

The **external skeleton** is made up of thirteen ring-like **segments**, with openings in these, generally on the sides of the body, leading to **air-tubes** for breathing purposes.

Each **winged** insect has two or four wings, and nearly all have six legs.

Insects have no **bones, lungs,** nor **brains** proper. An insect grows, but not after full emergence from its **pupa** case. When it becomes winged it is full grown, and changes its skin no more.

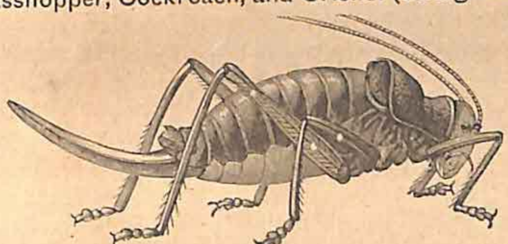
II. Divisions.—(1) **Beetles.**—These are distinguished by their strong **wing-cases**; the two fore-wings being hard and horny, to protect the hinder ones, which are larger, and can be doubled up under the cases. The "**cocktail**" folds its wings many times, by means of its tail which curves over the body. Their wings need this protection as the owners creep under stones, bark of trees, and rubbish.

Beetles also have **jaws**, as they mostly feed on solid food.

(*a*) **Water-beetles** have long, strong, flattened hind legs, which act as oars. In this respect they are like some crabs (*vide infra*). These legs are covered with **bristles** which can be used like an oar feathered in rowing. Water-beetles also have an air-cistern on the back, between the wings and the body; by expanding the wing-cases this is charged with air. The "**spiracles**", or apertures of the air-passages, are situated on the **back**, and not on the sides, as usual. Water-beetles feed on decayed matter, and thus retard putrefaction in the water in which they live.

(*b*) **Land-beetles** also feed on decayed matter, and some bury their dead prey to serve as a store of future food.

(2) **Grasshopper, Cockroach, and Cricket (Straight-winged).**—



Grasshopper.

These differ from beetles in having **straight** wings, only folded longwise, and not crosswise as well.

(*a*) The **Cockroach**, though termed a "**black-beetle**", is really brown in colour, and some are even white. The males only have wing-cases. The eggs are laid in a hard, horny case, eight eggs on each side, like peas in a pod. Hence it is difficult to get rid of cockroaches, as they increase so rapidly.

(*b*) The **green Grasshopper** lives in trees; the **brown** in fields; these leap, spread their wings, fly, settle, and then leap again. The male grasshopper "sings". The inside of the thigh has many hard, horny plates, which overlap each other and feel rough when rubbed the wrong way. The outside of the wing-cases has sharp ridges;

the legs are rubbed over these, and so sound is produced. The female has at the end of her body a flat, curved blade like a sabre, with which she works a hole in soft ground, like a carpenter using a bradawl. In this hole she buries her eggs. When the young crawl out of this they have no wings, but long hind legs for crawling and leaping.

(c) The **Cricket** is light brown or grey. It makes a shrill chirping noise by rubbing its wing-cases sharply against each other.

(3) **Dragon-fly (Lace-winged).**—All insect wings consist of a transparent **membrane**, stretched for strength on "**ribs**". The dragon-fly's ribs are so numerous that the wings seem made up of very many small cells like delicate **network**, and the Order is hence termed "**lace-winged**". Scarcely any other insect flies so fast as the dragon-fly; it can also fly backwards, as well as forwards. It feeds

Dragon-fly.

on other insects. As a grub it lives in water, feeding on insects there, and it can swim well. The end of the tail has a tuft with five projections, and a tube running up the centre. When this is filled with water the muscles contract, the water is forcibly ejected, and this striking against the outside water impels the insect on its way.

(4) **Bees, Wasps, and Ants (Membrane-winged).**—(a) **Bees.**—These are furnished with four transparent wings, the front pair larger than the hinder. When in use the wings are fastened together by a row of tiny hooks. All insects with **stings** belong to this group; but the "drones" of bees have no stings, only the "females" and "workers" being thus armed.

(b) **Wasps.**—The "queen" wasp makes her nest in the ground, often in a rat's hole, the first cells at the end, with an egg in each; and feeds the grubs when hatched. These become "**workers**"; the

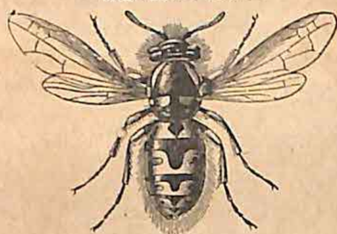
queen then does nothing further but lay more eggs. In winter all die except one or two females.

The cells are shaped like those of bees, but are not double, nor made of wax; they are only used as cradles for the young. The

Queen Bee.

Male Bee or Drone.

Worker Bee.



Wasp.

wasp nibbles soft wood, carries this to her nest, chews it to a pulp, and spreads it out whilst still wet. When dry, it is like thin paper.

(*c*) **Ants**, like bees, are **males, females**, and **workers**; the last group being subdivided into "**soldiers**", "**nurses**", and "**providers**".

Ants do not build cells, but burrow "**galleries**" under the ground. On a hot day the lower galleries are used; on a cooler one the upper, to get the sun's heat. The grub spins a cocoon, popularly called an ant's "egg".

Ants sleep through the winter. The "workers" never have any wings; and the males and females only retain them for a short time. The latter snap off their own wings, and then settle down to make new homes.

(5) **Butterflies and Moths (Scale-winged).**—(*a*) **Butterflies.**—The **wings** of this Order have beautifully coloured scales, fine as dust, of various **shapes**, arranged in **rows**, the rows overlapping in front like the scales of a fish. When rubbed off, tiny dots are

seen marking the places of their attachment. The wings themselves are like those of bees.

(*b*) Butterflies live on nectar, and have no jaws, but a hollow **trunk**, or **sucking tube**, to reach this sweet secretion at the bottom of the **nectaries** of flowers. The **larva**, or grub, is called a "**caterpillar**"; the **pupa**, a "chrysalis".

(*c*) The **hair** on the caterpillar of the tiger-moth is a defence against enemies, and when falling. The green caterpillar's protection is its **colour**, like that of the plants on which it is found. Others have a disagreeable **taste**, and so are refused as food by birds, and thus escape destruction. Caterpillars thus vary in colour, and some are smooth and others hairy.

(*d*) **Limbs.** Behind the small dark head there are three pairs of **legs.** Further back on the long abdomen, there are four pairs of short, stumpy "**feet**" to support the body. At the tail of some caterpillars is another pair, which act as "**claspers**" for holding on to twigs.

Butterfly and Pupa.

(*e*) **Air-tubes.** There are little openings on the sides of all the rings, except those of the head and the next two segments. These are the apertures of the "air-tubes".

(*f*) **Moulting.** The caterpillar spends most of its life in eating and sleeping. Soon its skin becomes too small, when the creature rests a little; the old skin cracks, and the animal creeps out—a changed creature. When it has got out of the old skin, in some kinds the late owner eats this up.

(6) **Change to Chrysalis.**—Before the caterpillar ceases feeding, a new skin, new eyes, and new legs are forming. When it has ceased to feed there is still a great change to come about. For this it must rest for some time, and become a **chrysalis.**

It spins a web on a nettle leaf, etc., and hangs down by its hind feet. It looks like a caterpillar; but inside there are all the parts of a **butterfly**, viz., long trunk, three pairs of legs, two pairs of wings, and an abdomen without any legs.

Now the outer skin falls off, and we can see these parts below.

Then it packs itself up with wings folded in front. A hard case is now formed to which the limbs are firmly fastened. Inside this case is a sort of living mummy. The creature inside now grows, and at last bursts this outer shell. The butterfly escapes, very weak at first, but soon becomes stronger, and flies from flower to flower, sucking nectar. At last it lays eggs on some plant, so that when the young caterpillars are hatched from these they may have food waiting for them close at hand.

As a rule butterflies are found in the day, and moths sleep then and fly by night.

(7) Defences of Insects.—These are very various and include :—

(*a*) The hard skins of some beetles.

(*b*) Some have hard, sharp spines.

(*c*) Others have a disagreeable taste, and so the race is protected.

(*d*) Some are hairy.

(*e*) Others look ugly.

(*f*) Some resemble the leaves they live on.

(*g*) Some resemble other, and often disagreeable, and stronger insects.

140. SILKWORMS.

INTRODUCTORY SPECIMEN LESSON.*

I. **Egg Stage.**—The female silkworm moth lays from 250 to 400 eggs, on mulberry leaves, which are to serve as the food of the future grubs. Each egg is nearly as large as a small mustard seed ; and at first is of the same colour.

II. **Caterpillar, or Larva Stage.**—This is the eating, and growing stage. The grub from the egg is about $\frac{1}{4}$ in. long, and like a small dark worm. About eight days after hatching, it "moults", or casts its skin, and is then of a greyish colour. It feeds for five days more, and then moults again, and does so a third and fourth time, with the same intervals for feeding.

It now has the scaly, short and curved limbs which will later become the legs of the fully developed insect. Behind these are ten softer "feet", like small pads, edged with tiny hooks, and called "claspers". The two at the tail can be turned inwards, like our finger and thumb, for holding on to twigs, etc. These ten "feet" are like inverted cones cut off, giving the grub a flat

*The "Special Information" on this subject is generally tolerably well known by class teachers ; where this is not the case the "Specimen Lesson" will require to be more closely studied.

sole for walking. This sole can be made hollow in the middle; and the hooks on the edge, when the foot is placed on a rounded twig, are obliged to bend inwards to get a firm hold.

The **mouth** is very large and strong, and suited to the large quantity of leaves eaten.

Below the jaw are two **openings**, giving out a sticky juice which hardens in the air into **silk**.

The **head** has two short **feelers**. The **eyes** are few, small, and on each side of the head near the top.

The visible openings to the **breathing-tubes** are on the sides, a pair to each segment, except in the second and third segments behind the head.

Before "moulting", the grub becomes sluggish, and ceases to feed. The old skin splits down the back (from head to tail), and the caterpillar wriggles out of it. It can thus increase in size. The old skin is always eaten from the head to the tail.

The second, third, and fourth segments represent the future chest (**thorax**); the rest, the belly (**abdomen**).

III. Chrysalis.—About ten days after the last moult, the grub seeks a fit place for forming its **cocoon**. It secretes a yellow transparent gum to make the silk. This is drawn through two very small openings beneath the jaws and close to each other. The caterpillar first moves its head about, and attaches its thread to different points to make a framework for the support of the cocoon. On this a loose, oval, structure is then formed. In this last covering in the next three days it spins a firm cocoon, or case of silk, round its body. When it has done spinning this, it smears the inside of it with **gum**. While spinning, it gradually changes the form of this, and when done it is an oblong, roundish ball, covered with a smooth, shelly skin; and is called a **chrysalis**, or **pupa**.

The creature's future **limbs** are packed up under the skin; the old **jaws** becoming transformed; and the old **eyes** more numerous, since a flying insect needs keener sight than a creeping caterpillar. There is now no more feeding. The soft case gradually hardens.

IV. The Moth Stage.—In nine or ten days the new limbs are fully formed. To get out of prison the insect moistens the gum inside the cocoon. Then with its head and feet it loosens and pushes aside the filaments of the cocoon, and escapes as a "perfect", pale-cream moth. The weak **legs** and **wings** soon become firm and strong. It lives only to lay from 250-400 eggs, with no further growth.

Only a few silkworms are kept to become moths. The rest are destroyed by heat to prevent the creatures inside from cutting their way out and thus spoiling the silk on the outside of the cocoons.

The next subject is rather more difficult than the preceding, and not generally quite so well known by junior teachers; but a careful study of the "Notes" will give the class teacher the required "Special Information".

141. FIRST NOTES OF LESSONS—BEES.

Matter.	Method.
I. Introduction— Insects have no *backbone*, nor any other bones. Their skin is often firm and hard, making an external skeleton. They have no *heart*, nor *brains*. All are *jointed*. The body is divided into *three* parts. They pass through *stages*:—*Grub*, *Pupa*, and *Perfect Insect*. We have seen what are the parts of insects generally. These same parts are seen in the bee.	I. Show the various *stages* of life of a butterfly or moth; and point out on a living specimen of the honey-bee the general features of insect structure mentioned in the "Matter" column. Have a living honey-bee, and humble-bee, under a glass tumbler for the class to see. Draw on the blackboard from a diagram the three separate parts of the honey-bee.
II. The Head— This corresponds with the head of many other insects, in having a *mouth*, *feelers*, *eyes*, *jaws*, and *tongue* or *sucking-tube*. The sucking-tube is to collect the "nectar" from the "nectaries" of flowers, as the raw material which is to be manufactured into *honey*, inside the honey-bee.	II. Point out on a diagram the parts of the *head* indicated; and explain their *structures* and *functions*. Show a piece of *honeycomb*; and let the class see that it is made of *thin wax*. Refer to the sweet juices of flowers, not as "*honey*", but as the raw material to be manufactured into this by the bee.
III. Chest or Thorax— To this the limbs are attached; two pairs of *wings*, and three pairs of *legs*. There are three rings in the chest. (*a*) *Wings*.—These in function are like the organs of locomotion in Mammals, Birds, Reptiles, and Fishes. They are in *pairs*. These lie one over the other, and are not more than one-fifth of an inch across when folded up, so as to be suitable to the size of the cells in	III. This is between the head and the belly (abdomen), as may be shown in a diagram, and on a dead or a living specimen. (*a*) Call attention to the fact that Insects have none, one, or two pairs of wings, according to their needs, *habits*, *dwelling places*, etc.; illustrate by the house-fly, flea, and bee. Some have wings for a *time* only, as in the ants. Compare the folding of the bee's wings in the cell, with that of the *leaf* in the

NOTES OF LESSONS—BEES—*Continued.*

Matter.	Method.
the comb. They are joined by hooks; and form only one connected surface in flight. Buzzing is produced by the beating of the wings.	bud; and unfold a leaf-bud just about to expand.
(*b*) *Legs.*—These, with the hairy chest, are specially suited for gathering the yellow dust (*pollen*) from flowers. This is made into "*bee-bread*" for feeding the young. The chest and legs are covered with *hairs*, for (1) *Gathering pollen* (especially the hairs on the chest). (2) For *Clothing* to keep the body *warm*. (3) For *protection* against blows, friction, etc. (4) The front-leg hairs are used for cleaning the feelers; and may thus be compared in employment with the cat's tongue used in cleaning its face, or with a child washing itself. (5) For "baskets" on thighs, for carrying pollen on the third pair of legs, from the flower to the hive.	(*b*) The *pollen* from any ripe flower, as the buttercup, etc., may be shaken out on a slate for the class to see. Compare the bee covered with this to a dusty miller covered with flour. The *hairs* on the bee may be compared with those on the hairy caterpillar; with the whiskers on a cat; with the hairs on a crab's legs; and with the upright stakes in a hay-waggon, used to keep in the hay. Draw the third leg, in cross section, and show:— (*a*) The inside supplied with combs. (*b*) The *outside*, which is hollowed. (*c*) On the outer edge of this hollow "basket" are *strong hairs*. Illustrate the combing of the pollen from the chest-hairs, and the placing this into the "*thigh-pockets*", by our right hand gathering something off the chest and placing it in an outside pocket. Point out that these "*pollen-baskets*" are found only on the "workers"; not on the "queen" nor the "drones".
IV. The Belly— Here are found in the bee:— (*a*) *Breathing holes* and tubes. (*b*) The *sting*. (*c*) The *stomach* inside. (*d*) A *storehouse* for *honey*, gathered as nectar by a rough tongue. (*e*) An apparatus for making *wax*.	IV. (*a*)-(*e*) Show the position and structure of the *belly* on a live bee, and on a diagram. Call attention to its *rings*, and to its absence of *limbs*, and to the *sting* at the end of it.
(*a*) *Breathing holes and tubes.*—On the bee's belly only six rings are plainly marked. Between these on each side, and between the upper and lower half of the rings, are the bee's breathing holes.	(*a*) Refer to insects living a long time under water without drowning, because of the air in the *air-tubes* inside their bodies.
(*b*) The *sting* is on the hinder part of the body, and is supplied with poison. It consists of (1) *sheath*, and (2) two barbed *darts*. These latter act like the barbs on a fish-hook in penetrating our flesh; so that when the bee hastily	(*b*) Point out the convenience to the bee of the position of its sting; and compare this in function with the snake's poison from fangs, both being in a kind of sheath. Illustrate this in the bee by the scabbard of a sword, by a bodkin case, by scissors' holder, etc.

NOTES OF LESSONS—BEES—*Continued.*

Matter.	Method.
tries to withdraw its sting, the barb retains it in the flesh; and the bee dies from losing a part of its own body.	Compare the barbs on a bee's sting with those on an arrow-head; draw a diagram of them both on the blackboard; and also of the king-fisher's barbed tongue; and show the similarity of function of all these.
V. Where the Bee Lives— In *hives* near gardens. Bees also in a *wild* state live in *holes* in the ground, under *roots* of trees, and in holes in their *trunks*.	V. Get the "*habitats*" of the domesticated, and of the "bumble-" or humble-bee from the class, in the country. Tell town children these, and tell both where wild bees live in Africa, America, etc.

142. SECOND NOTES OF LESSONS.—BEES.

Matter.	Method.
I. Kinds of Bees— (*a*) *Queen*; (*b*) *Workers*; (*c*) *Drones* (males). (*a*) *The Queen.*—Children have a general notion that the queen bee *rules* the hive, as our Queen Victoria rules us. But the special, and most important, work of the queen is to *lay eggs*. She is the *mother* bee rather than the *ruling*-bee. She is much larger than the "worker" or "drone".	I. (*a*) Compare the order and industry in a *hive* with these in a *school*. Call attention to the beautiful results obtained by animals thus combining in "subdivision of labour", as in bees, ants, etc. Compare with the similar results obtained by men, as in a shoe factory, etc., where each hand is told off to do one kind of work only.
(*b*) *The Workers.*—These are the smallest of the three kinds; and are provided with "*pollen-baskets*", *stings*, means for producing *wax*, and for gathering materials for *honey*.	(*b*) Compare the "pollen-basket" with the side pocket with open mouth in a lady's jacket.
(*c*) *The Drones.*—These are few in a hive; and they do no work. The body is *broader* than in the other kinds, longer than in the workers, but shorter than in the queen. Drones have no *pollen-baskets*, and cannot make *wax*. When food runs short, they are killed by the workers biting them close to the wings.	(*c*) Compare the *drones* with idle, useless people; and give the class the text to repeat; "If a man will not work neither shall he eat". Show to the class specimens of all three kinds of bees, or drawings of these: and on them verify the points indicated in the "Matter" column. Remind the class that the bee is given as a *model* of industry, as seen in the phrase, the "busy bee": but that it is the *workers* that should have this title.
II. Life in the Hive— (*a*) *Making Wax.*—In an empty hive, bees first build up a *honey-comb* of many *cells*. The workers	II. (*a*)-(*c*) Show a picture of bees hanging down from the roof of a hive whilst making *wax*.

NOTES OF LESSONS—BEES—*Continued.*

Matter.	Method.
first hang from the roof; and then the *wax* comes out from their bodies. These *plates* of wax are drawn from their "*pockets*", are then kneaded by their teeth and jaws, and mixed with saliva, and so at last made ready for comb-building, or the making of the cells.	Show a diagram of the under side of a bee, with the *wax-plates* sticking out of the six "*pockets*" between the rings. Point out that wax is not gathered, but *made*, by the workers.
(*b*) *Shape of the Cells.*—These are six-sided, and in size are about one-fifth of an inch across, but all the cells are not of the same size. The *queen* cells are larger, and of special construction. The cells for *drones* are larger than those for the workers. The six-sided shape allows each cell to lie against the next without loss of space or material. (*c*) *Use of Cells.*—The cells serve as *storehouses*; some for *honey*, some for *pollen*, and others for *eggs* laid by the queen. The *first* will store up the honey, which is half liquid, for winter use as food: the *second* similarly store up the pollen to be used as food or "bee-bread" for the young: the *third* serve the purpose of the nest to eggs in Birds.	(*b*) Tell children that bee-keepers provide the honey-comb, instead of letting the bees make it. This is done because the wax comes from the food of the bees; so instead of using food to make wax, more *honey* is thus obtained in the cells. Twenty pounds of honey are required to make one pound of wax. Show a picture of a "*swarm*" of bees clinging to tree, etc.
III. Life of a Bee— (*a*) The queen lays an *egg* in a cell: this hatches into a *grub*. But the grub cannot find food for itself, so the young workers, or nurses, provide bee-bread made of honey and pollen for it. For four days the grub is fed, and becomes a "baby", or *chrysalis*. It is now sealed up in its cell for fourteen days. Then it comes out as a "*perfect insect*"; and twenty-four hours after works as a "nurse". (*b*) When the bees are too many for the hive, the queen calls some together; and goes off with them to find another home. This is called "*Swarming*"; and bee-keepers keep empty hives ready	III. (*a*) Compare with the early life of an *infant* (the grub), living in a *cradle* (the cell), and being fed by its *brothers* (the "workers"), under the direction of the *mother* (the queen). Compare the pollen and honey with bread and treacle. Compare with an Eskimo baby wrapped up tight, and strapped on its mother's back, with only its face visible. Illustrate by the *grub*, *pupa* and *imago* (perfect insect) of white butterfly. Tell the class that the butterfly does not act as a "nurse"; and does not live through the winter (as a perfect insect). (*b*) Tell the anecdote of a swarm settling on a girl's face, and being got rid of by the removal of the queen followed by that of her subjects. Compare with the settlement of a new colony under a leader, when the old

NOTES OF LESSONS—BEES—*Continued.*

Matter.	Method.
for this. Before the queen goes off, a young queen has been already hatched in the hive, who becomes the head of the old hive. Sometimes two or three swarms go off from one hive in a year.	country has become too thickly populated.
(*c*) In *winter*, bees live on the honey gathered in the summer: but the drones are first killed. If but little food is left, as after a cold summer, the bees die, unless provided for by the bee-keeper, who gives them syrup made of sugar.	(*c*) Remind class of the various ways animals have of outliving the winter. Some lie *dormant*, as dormice; some *migrate*, as swallows; some get *warmer* coverings, as birds that moult, animals that thicken their fur, etc.: others *lay up stores* of food, as the squirrel, bee, etc.
IV. Honey— Sweet juices are gathered from flowers by the long hairy tongue; and are passed into the "*honey-bag*" (not into the stomach). For the bee to use some of this honey for its own food, there is an *opening*, the "stomach-mouth", from the honey-bag into the digestive organs. This juice undergoes in the honey-bag a great change in colour, taste, and smell. It is at first "cane-sugar"; but afterwards becomes honey containing "grape-sugar".	IV. Give the children some flowers containing nectar to suck, such as the honeysuckle, to show the source of the *materials* of honey. Point out the secret nooks and hiding places for this nectar in different flowers; and the skill of the bee in finding these out; and the beauty and fitness of the sucking-tube for reaching it. Refer to the long tubes and side pockets of the "*nectaries*" of flowers, and the corresponding long "trunks" (coiled up when not in use), of insects frequenting these flowers.
V. Uses— (*a*) *Wax.*—(1) For Candles. (2) For artificial flowers and fruit (the wax is cleaned by melting, strained through hair-bags, and bleached). (*b*) *Honey.*—Food for *bees* and for *man*; and used for *medicinal* purposes.	V. (*a*)-(*b*) Get as many of these as possible from the class; and show a bit of wax-candle, beeswax used for sewing, wax artificial fruit, honey-comb, and some honey. Remind class that honey was used instead of sugar in olden times, and refer to Scriptural mention of it. ("Land of milk and honey", etc.)
VI. Lessons— (*a*) *Industry* from the "workers", all drones being killed. (*b*) *Thrift.*—Storing up in summer, for winter use. (*c*) *Obedience*, *Method*, and *Order* in work.—Each has its own work, which it does well.	VI. (*a*)-(*c*) Read to the class Henry V., Act I., Scene 3, and get from the class the points noted. Enforce the lessons of thrift and kindness to animals, especially to those which are always profitable even to ourselves.

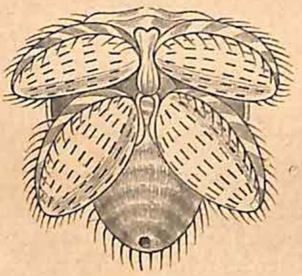
JOINTED ANIMALS WITH EIGHT LEGS.

143. THE HABITS OF SPIDERS.

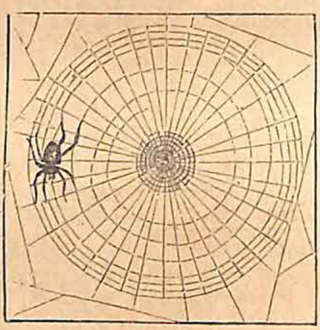
FIRST SPECIMEN LESSON.

I. **Webs.**—Garden spiders **spin** their threads; and **weave** these into **traps** and **snares**, or spiders' **webs**. They first stretch out eight or ten **outer** threads as a framework to support what follows. These they spin in **double** and even **treble** strands; as they know they will have to stand the greatest strain. Next they connect these by **thinner** threads crossing the outer ones and spreading out like the **spokes** of a wheel, and, like these, all connecting at the axle, or **centre**.

This gives the **scaffolding** for the house; or the **woof** on which the **weft** is to be woven. This latter is begun at the centre, and carried round in an ever widening **spiral** to the outer threads.



Spinnerets.



Spider's Web.

This spiral is the part of the net which is most used to entrap insects; and for this purpose it is **beaded** with sticky, gummy drops like **dew**, which glue down the insect, as treacle does stray flies walking into it. This part is **renewed** every morning to ensure a supply of fresh sticky gems on it.

II. **The "Dew".**—But the spider does not merely live perched in this web. She either hides in a hole in the **centre**, hanging head downwards in it; or she makes a special **house**, or hiding place, under a leaf near, or in an adjoining corner. In either case she waits for her prey, like an angler with his finger on the line ready for the slightest pull on it. Her **feet** hold the lines of her web: and if one of these but **slightly** moves, she knows she has caught a

small insect and pounces on it at once. If there is a stronger pull against it, she knows her prey is larger; and, therefore, shows more caution in falling on it.

If it is a wasp, she rolls the prisoner round and round by the head; keeping, however, at a safe distance from its sting, until it is bound a helpless prisoner in the meshes of the web. Then she sucks its blood. But, if it is a humble-bee, she lets it tear its way by its own strength out of her web, as she knows it is too strong for her to master.

III. A Poisoner.—All spiders have poison-fangs. These are in the jaws. This poison aids them in securing their prey, like the poisoned arrows of savages. It, perhaps, also takes away the pains of death in the victim.

IV. A Murderer.—It is the female spider that spins the web, and kills the prey. She is not only, however, a murderer in doing the latter; for she often kills her husband, the male spider, as well. And not content with being thus a murderer of the worst kind, she is a cannibal also; for she will sometimes eat him up, after she has killed him.

144. SPIDERS.

SECOND SPECIMEN LESSON.

I. Insects.—(*a*) Legs. All animals that have six legs, in three pairs, coming off from the middle of the body, we have already called Insects.

But if we look at a spider, we see that there are eight legs, in four pairs; so the spider is not an insect. It is very common, however, to call all animals insects which are small, since insects are mostly so: but this is not right, as we now see.

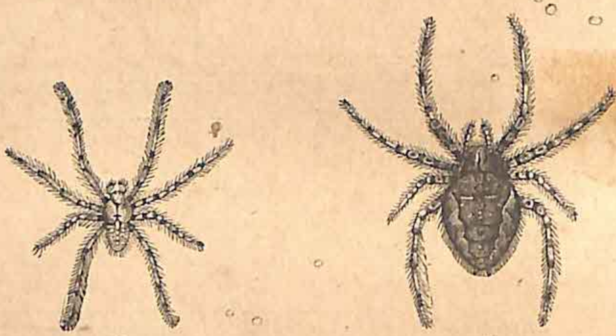
(*b*) Segments. In Insects, again, the head is mostly distinct from the body. But the spider's head and the middle of the body are all in one; or the animal is in two parts, not in three, as in Insects.

(*c*) Feelers. The spider also has no feelers, which are those long thread-like parts of the body which we see in the lobster, in which animal they reach back to the end of the tail.

II. Detailed Structure.—The spider's skin is very soft, and not covered with shell, like the crab and the lobster; nor with scales, as with butterflies. Its limbs also are not fastened to the body very firmly, so that they can be easily torn away.

III. The Spider's Web.—At the hinder end of the body the spider has little swellings, like **nipples**, called **spinnerets**; and through the openings in these the threads pass out that make the **cobweb.** At first these threads are very soft, like gum; but as they come out to the air, they **set**, or become hard. If we watch the spider spinning her web, we see her cross one thread over the other, while both are still soft. She then **treads** on the threads at the points where they cross: and thus makes them stick together as well as if they were tied in a knot.

She draws the threads with her hind feet out of her **body**, through the nipples, or "spinnerets". She first stretches the **outer** threads,—or the long lines like the spokes in a wheel,—by fastening the ends to some fixed objects, such as door-posts,



(1) (2)

Garden Spider: (1) Male, (2) Female.

twigs of trees, etc. She next lays the thread down in "cork-screws", or **circles**, round and round; passing them over these straight lines. The circles, or spirals, become larger and larger as they extend towards the outside of the web.

Woe to the **fly** or **gnat** that then buzzes into the web; the more it tries to get away, the faster fixed it becomes. And if it breaks the thread, the spider rushes out of her hole and throws another thread or two over its wings, or legs, until the poor creature becomes tired of any longer trying to get away. The spider then comes to her weary prey, kills it, and sucks its juice or blood, sometimes leaving the body for a meal for a future time.

We sometimes see, however, that a **bee** gets caught; and then it makes short work with the web. Unless the spider is very hungry, she lets the bee get out again. She is, indeed, very glad when it is

free; for it mostly breaks up the web, and leaves her a lot of "mending" to do.

As she spins her web, she uses up the stuff of which the web is made; and so, if we break down the web time after time, at last she cannot spin another. Then she seizes another spider's web.

IV. Other Kinds.—Some spiders can live in water as well as on land; and for this reason these are called **water-spiders.**

There is another spider in England which is very small, and is found by thousands in fields, gardens, and on roadsides. This kind can jump off from twigs, and be held up in the air, or blown by the wind, while it spins its web. It is in this way able to carry a cobweb right across the road, from hedge to hedge. We very often notice these fine cobwebs or gossamer at the latter end of the autumn. They are covered at morning-time with fine, white, shining beads of dew which have fallen on them in the night. These keep there till the sun dries them up. They are also found on railings in early winter, being then covered with needles or crystals of ice, which melt into beads of water under the warm breath, or when the sun shines on them.

Hunting Spider.

V. Uses.—Spiders are **useful** to keep down the number of flies. But they are a hateful sight in a **house**; and show that the people there are untidy and unclean. Cobwebs should always be swept down with a broom; and for this reason walls and ceilings require sweeping, as well as floors.

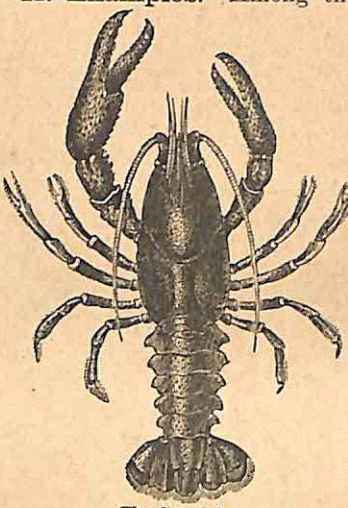
145. NOTES OF LESSONS—SPIDERS.

Matter.	Method.
I. Where Found— Spiders and spiders' webs are found in neglected *corners* of the house which are not often swept out; and in *holes* in garden walls, trees, and out-buildings; and some make holes for themselves in the *ground*. The latter kind cover their hole with a trap-door moving on a hinge, which they have made themselves for this purpose—the door out of earth and web, and the hinge from cobweb.	I. Refer to spiders' webs, found in *houses* and *gardens*, and ask children for a description of these; and draw one on the blackboard, and call attention to the *radiating* and *concentric* threads in it. Show a picture from a reading book of the spider watching for prey in her hole in the ground; and also of the *trap-door* when opened. Let children note that spiders will be found wherever their *insect food* can be obtained.

We thus get the following table :—

ARTICULATA	1. **Insecta**: bees, etc.
	2. **Arachnida**: spiders, etc.
	3. **Crustacea**: crabs, etc.
	4. **Annelida**: worms, etc.
	5. **Myriapoda**: centipedes, etc.

II. Examples.—Among the best known of the subdivision with ten legs are the **crab, lobster, shrimp,** and **prawn,** all living in the **sea**: and the **cray-fish,** found in the **fresh** water of rivers.



The Crayfish.

III. The Crayfish.—This is very like the lobster in **shape,** but generally smaller in **size.** Like the lobster, shrimp, and prawn, it has its abdomen **extended,** not tucked beneath it as in the crab. It does not turn **red** in colour after boiling like the lobster.

The **skeleton** is hard, and mostly made of **salts of lime**; and consists of plates of **shell,** with softer **skin** between them to allow of motion. At first the shell is soft; but it hardens with growth, from the salts of lime taken in with the food and laid down as shell on the outside of the animal.

If we put a piece of this shell into strong vinegar the acid dissolves out the lime-salts in it; and what is left becomes quite soft as at first.

Parts.—(1) The **head** and **thorax** are united; but there is a **groove** showing where these join; and on the underside there are divisions somewhat like the rings of the belly. This front part projects over the sides, having the **gills** beneath it.

(2) The **abdomen,** or belly, is made up of **seven** parts, or **segments,** of a **ring-like** form, the last portion being a broad flap. The six parts move on each other easily, for they are connected by a pliable skin which acts like a hinge.

(3) The **legs** are fastened to each hard ring of the belly, four on the chest-rings for walking, two pairs with pincers or claws for climbing, seizing prey, tearing food, carrying this to the

mouth, etc. Others are **foot-jaws** for grinding hard food, such as snails, insects, etc.

Crayfish live in holes in the banks of rivers.

Casting shell. In most other animals the **skin** grows with the **body-flesh** beneath it; but in the crayfish (lobsters and crabs), it is not so. In order to increase in size they must **cast off** their skin, or burst it. A soft skin forms beneath the hard one. At the time of the changing of the skin, the creature is generally sluggish. The skin is changed several times during growth.

IV. The Crab.—(1) Here we also have a united **Head** and **Thorax**: ten limbs in five pairs, all jointed; but the lower part of the body is tucked under the combined head and thorax.

(2) The **Eyes** are **stalked**, and enable the owner to see its prey even when it is itself buried up to the eyes in sand.

(3) The **Jaws** are used for grinding; and the owner is an animal feeder.

In some crabs, the **limbs**, or the hinder ones, are **flattened**, to allow of swimming motions.

(4) The **Gills** are in pairs at the sides, and under the cover of the shell; and are known as "dead-men" from their livid colour when boiled.

V. Prawns are very like lobsters in **shape**; and like them, too, in living in holes of **rocks** in the sea.

VI. Shrimps are shaped like prawns, but without the beak (rostrum); and they are of the colour of the **sand** in which they live at very shallow depths of water.

147. THE CRAB.

INTRODUCTORY SPECIMEN LESSON.

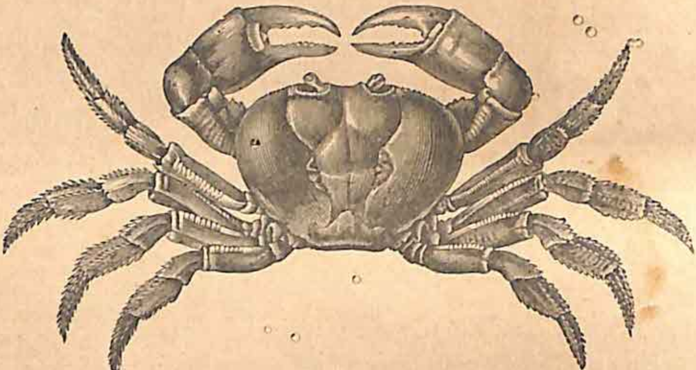
I. Introduction.—All children who have been to the sea-shore must often have seen alive the animal of which we have the picture before us. We know at once that this is a crab. But there are many **sorts** of crabs, though all alike have **ten legs**, in five pairs on opposite sides of the body, and a **hard shell.**

II. Dog-Crabs.—Dog-crabs are found in the sea in large numbers under almost every rock, and in every rock-pool. They are either **red** or **green** in colour. Both kinds are caught by boys for eating, but they are not nearly so nice as the crabs sold in shops, and never grow to so large a size.

They may be seen coming out of their **holes** and from under the **sand**, where they have been hiding all the while the tide was out.

As soon as they feel the ripple of the outer and colder water of the sea coming into their ponds, they sally out for the food which the tide generally brings in with it. Before this, if we had looked for them, we should either not have seen them at all, or only their eyes a little above the level of the sand. We notice that these eyes are placed on stalks.

They have their legs tucked under them while they keep quiet in their holes in the wood of jetties and groins along the coast, or in the cracks of the rocks, or under stones. We can tempt them out of their shelter, however, even when the tide is out, as they are very greedy feeders. In fact, they are like scavengers in their collecting refuse and offal. They feed on almost any kind of dead flesh or fish, and do not at all care for it to be fresh; indeed, the less fresh



Land Crab.

their food is, the more they seem to enjoy it. So boys use, to catch them, the waste parts of fish, such as the head, and the insides thrown away with the head when the fish is cleaned for table. These they tie on a string, and sink the whole with a piece of iron or lead, or by means of a stone with a hole through it. This bait is let down either into the sea near a groin or jetty, or into a rock-pool.

In a very few minutes, one, two, or sometimes three or four crabs at a time, run out to this bait from their hiding-places in the rocks or sand. They either smell, or taste, the bait through the water. They then fasten on this with their long nipping claws, and their grinding jaws are soon set to work eating their dinner. They are so greedy, that the boys may now pull up the stone, bait, crabs and all, and put the latter into their basket. In this way sometimes

two or three hundred shore crabs, as the dog-crabs are commonly called, are caught in an hour.

III. The Edible Crab.—The proper eatable crab is of a rather different shape from the dog-crab, and not of the same colour; it also has different habits. It is more oval. In colour it is red, and white beneath, the red not being so dark coloured as in the red dog-crab. It is also not so greedy, but generally keeps quite still under rocks and in holes until the tide has risen, not often being tempted to come out of its shelter till then. It is caught by bait, which is put into a "crab-pot", or a basket with a large bottom and small top, open above. Bait is placed in this basket, and the whole is dropped into a rocky place which these crabs are known to frequent. Then the crabs crawl or swim up above the level of the basket, and drop down into it through the open mouth. But, when once in, they cannot get out again, for the mouth of the basket is partially closed with netting. So there they are kept prisoners until the fisherman comes to draw up the crab-pots. He knows where these are by means of buoys, or floating corks, which he tied to the baskets, and which float just over the place where he dropped them.

IV. Casting the Shell.—Once a year the crab gets a new greatcoat; that is about Easter. The crab then throws off the old shell from its back and limbs; and, after this, it is in a sorry plight until a new shell grows again. If we look at the under side of a crab's shell, we see the parting where the shell splits. This is shown by the mark which is left round the under edge of the shell.

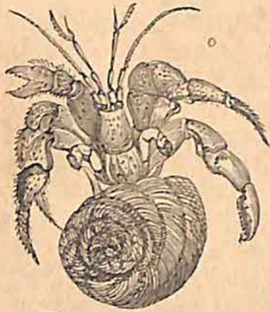
Just after the crab has changed its shell, its back is, of course, quite soft. Then its flesh is so full of water, and the whole is so light, that it is quite unfit for eating. When caught in this state, it is generally thrown back into the sea to grow up and thrive. But cod and other fishes eat them by thousands at this time, as they cannot then in their defenceless condition help themselves.

V. Habits.—Crabs are very quarrelsome. If we tease one with a piece of stick, it will often get so angry that in a rage it will bite off some of its own limbs, as if indeed they were those of an enemy. They often lose a limb in a fight, so that it is no uncommon sight to see a crab without some of its legs or claws. These, however, will grow again. A crab looks very droll when a young limb thus sprouts out to take the place of an old one.

VI. The Hermit Crab.—There is a crab found on the sea-shore of our country, which is called the hermit crab because it lives alone like a hermit. This has a very soft belly; but the front of its body is armed, as in the other kinds, with claws and a shell.

To cover this soft hinder part, it gets into a shell that does not belong to its own body, such as that of the whelk.

It is a very amusing sight to see the hermit crab changing its whelk shell, when it has grown older and larger, and wants more room. It goes trotting along the sands, dragging behind it the shell it has lived in by a twist in its "tail". When it comes to another cast-off whelk shell it gets into this, belly first, and turns its body round and round in it to see how it will fit. If it likes this shell, then the old one is cast away. If not, it again gives a turn or twist to its "tail", catches up the old house again, and once more goes forth on its travels until suited with a lodging.



Diogenes Hermit Crab.

VII. Limbs.—If we notice a common crab's legs, we see that the hinder and smaller ones are somewhat flattened. This is to help the animal swim through the water. If we drop a crab into water, we find that it does not sink like a stone; it swims in a crooked line to the bottom of the sea. These limbs are flattened like the blade of an oar, and for the same purpose, namely, to offer the least resistance to motion through the water.

148. DEEP SEA LIFE.

INTRODUCTORY SPECIMEN LESSON.

I. Chalk-Formation.*—The weak things of the earth—the humblest and smallest—perform some of the most important tasks in building up this world to make it fit for the "lords of creation" to dwell in. Thousands of square miles of the earth's surface, and hundreds of feet of its thickness, are mainly composed of the microscopic "shells", or "tests", of creatures of simple and lowly life, about to be briefly described. What they lack in size, they make up in numbers and in the long ages they have been found on the earth.

II. Nature of Chalk.—If the soft mealy "ooze" of the bottom of the Atlantic be examined under the microscope, it is seen to be mostly composed of these broken "shells". If a camel-hair brush be passed over a piece of common chalk and afterwards washed in

* *Vide* pp. 67 and 271.

a glass of water, the dried sediment thus obtained shows this to be the case. So our chalk Downs, and the beds of chalk beneath the English Channel, were made, for hundreds of feet in thickness, by these millions of creatures in years gone by.

The greater part of these "shells", or "tests", consists of chalk and limestone; but some parts are made of flint. The "shells" are of all kinds of beautiful shapes; but all alike have been made by similar jelly-like animals.

III. The Builders.—At first these consist of a single cell; but as they increase, other cells are built up on the first one. Some of the shells make a straight line; others are curved in all kinds of beautiful shapes. All remain connected with each other, to be washed up by the waves of the sea and carried inland by the breezes. They often make up miles of so-called white sea "sand"; and we tread them under foot, not thinking of their numbers nor of their beauty.

IV. Larger Forms.—Besides these smaller forms of animal deep-sea life, there are other and larger ones, such as star-fishes, and sponges. There are hundreds of different sorts of each of these two; and specimens are washed ashore after every storm at sea. Men have found them at the greatest depths to which they have sounded, and in all parts of the world. So we must remember that it is not the surface of the land alone that is full of animal life, but the "great and wide sea also, wherein are things creeping innumerable, both small and great beasts".

V. Vegetable Life.—But besides animals, there are also Plants at the bottom of the sea. These are the larger and smaller seaweeds, and other water-plants too small to be seen with the naked eye.

149. FORMS OF LOWER LIFE.

SPECIAL INFORMATION FOR THE TEACHER.

I. Microscopic Forms of Life.—These lowly creatures may often be said to be "built on no plan at all". They are generally found in both fresh and salt water; and a few only are visible to the naked eye. They carry on life, not by means of special organs set apart for special purposes: but the whole animal is at once a circulatory, digestive, and respiratory machine.

The body as a whole consists of a semi-fluid jelly-like substance.

II. Parasites.—Some are parasites, or "guests" living on, or inside, other and larger animals; feeding on the animal juices of

their "hosts", and turning these into their own tissues, just as the mistletoe does on the apple or oak tree.

(1) They may be destitute of a mouth;—

(2) Or, of the organs of locomotion.

They thus cannot themselves go in search of food, so they live on that which their hosts provide for them.

III. Pond Life.—Others are found in the fresh water of ponds and streams, and these have organs of motion or locomotion. They often attach these to a fixed object, and drag the rest of the body up to the point of attachment. Almost the whole of the body consists of a thin jelly, or gum-like substance.

There is no mouth, but any part of the outside of the body allows food to pass into it; and the food having been digested in any part inside, the refuse is passed out again through any other part of the outside.

These are creatures without any inside organs (heart, lungs, muscles or nerves); organs of special sense (sight, hearing, smell, taste, etc.); mouth or stomach: yet perfect in their kinds, and fitted to their surroundings.

IV. Common Sponges are found in both fresh and salt water. The sponge consists of a skeleton common to thousands of "sponge-particles", or "sponge-flesh"—which is the living portion. The framework, which is horny, made of lime, or flint, is the dead or formed material.

Sponges are found rooted to rocks at the bottom of the sea, in rock-pools, and in ponds;—in our own country and elsewhere, especially in warm countries. Being thus rooted, they were once considered to be vegetable. But the living part consists of jelly-like masses as in the preceding case, with the difference that the latter are free and single, while the sponges are fixed and collective; or live in colonies.

The "pores" and "mouths" in the sponge skeleton allow currents of water to pass in and out. These passages opening into and out of the sponge are not all of the same size, as may be seen with the naked eye

150. LIFE-STORY OF SPONGE.

INTRODUCTORY SPECIMEN LESSON.

I. What Sponge is.—What a battle has been fought over me! Some would have it that I was a plant; and others that I was an animal; and, of course, I could not be both, any more than

a cow could be both cow and grass. Fast and furious the struggle has been! You all know me as seen in the shops; but perhaps not very many of you have seen me alive on the sea-shore. And yet I am very common there too. Not as large as a bath sponge, it is true; but in long finger-like masses, growing in rock-pools and rooted to stones. What you see in the shop is not the true living sponge; but only my skeleton, on which the living animals, or rather our family of animals, were built up.

I myself, the true sponge, am one of the very small jelly-like creatures that once covered the sponge of the shops all over, inside and outside, with a slimy kind of flesh, made up of thousands of little jelly-like lumps like myself.

So when men collect us from the bottom of the sea, the first thing the fishermen do, if I may call those fishermen who catch no fish, is to get rid of us, the living part. It is only our horny house that they want: so they put us into the sun to dry up or rot away.

II. Structure.—You notice what a number of holes there are in the sponge; some large, and some small. These go down deep into the substance of our skeleton, and branch out on all sides, so that the sponge is as full of passages as an ant's nest, or as a very "spongy" loaf of bread. These holes and passages are to let water in and out.

As the fresh or sea water, for we live in both, comes in at the smaller openings, it is passed on, to go out of the larger ones. But the water, as it comes in, brings in with it small particles on which we feed. These are too small for your eyes to see; and we ourselves have no eyes to see them with. But for all that we manage to lay hold of them as they come floating by, just as easily as you may stand by a river's bank and angle out the fish as they pass on with the stream. I dare say you wonder what makes the water come in, and go out, through the small and large openings I speak of. Well, if you can only get it to come in, it will be sure to go out again.

Just think what you do when you want to make a current of pure air go through the underground passages of your coal-mines. You dig down in the earth and make two great shafts, like wells; these are like our "pores", or openings in the sponge. Then you connect the bottom ends of these shafts by underground passages, also like those in our sponge. The next thing is to make the air go up one of your shafts. This is done by turning it into a kind of chimney, by lighting a large fire near the bottom of it. You know

the hot air goes up the chimney over a fire-place because it is lighter than cold air.

So we sponges suck in the water through the little openings in our house; and then the water is forced out through the larger holes. But you will ask how we do this. Some of us have long whip-like threads fastened to our bodies; and we whip these thongs, all in one direction, and so sweep the water in from the outside through the smaller openings.

III. Different Kinds of Sponges.—The sponges which you wash with are horny and rather soft; but some of my brothers have flinty houses made up of rods and stars of flint, and you would not like to wash with them. Others, again, have a kind of lime in their skeleton; so we are divided into three kinds for this very reason.

IV. Fossil Sponges.—We have been a long time on the earth, far longer than men; and you will find us in a fossil state, that is, turned into stone, in some of the oldest rocks. You have been told the life-story of a piece of chalk; and I was alive in vast numbers when the chalk was being laid down at the bottom of the deep. In fact, many of the flints that you were told of as being in the chalk have been formed around the sponges. When you break lumps of flint with a hammer, you very often find sponge inside turned to stone.

151. SOME SIMPLE KINDS OF PHYSICAL APPLIANCES.

Course I.—These are such as depend upon physical, rather than on mechanical principles; or those dealing with the properties of matter not employed in the "Simple Machines", or the "Mechanical Powers".

Of these, three are suggested in the Schedule to be dealt with:

(1) The Thermometer, for measuring temperatures.

(2) The Barometer, for measuring the weight of the atmosphere.

(3) The Spirit-level, for obtaining horizontal lines and surfaces.

(1) The first depends on the physical principle of Expansion by Heat.

(2) The second makes use of the physical Law of Fluids, that pressure is transmitted by them undiminished and in all directions.

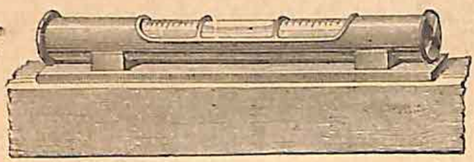
(3) The third calls in the aid of another Law of Fluids;—that these always seek the lowest level, in obedience to the Law of Gravity.

152. THE SPIRIT-LEVEL.

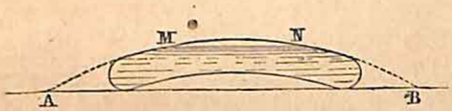
SPECIAL INFORMATION FOR THE TEACHER.

I. A Horizontal Plane.—A plane is a surface in which, if any two points be taken, the straight line joining these points lies wholly in that surface. As examples, we may take a slate, a sheet of paper, the floor of a house, and most of its walls.

This plane, however, may be set at any angle with the level of the sea, which is taken as the standard because it is constant, or uniformly level, with the small exceptions of tides and waves.



If the plane be perpendicular to this uniform standard, we call it a vertical plane; if parallel with it, a horizontal plane.



II. Application in Building.—In a house, for the purpose of stability, most of the planes are vertical, or horizontal. There are some sloping or inclined planes, as the roofs and gables; but the outer walls and the floors are all vertical or horizontal.

It is therefore necessary that we should be able rapidly, and accurately, to refer these in building to the standard level.

This is done in the case of vertical planes by the use of the plumbline, which is perpendicular to the level of standing water; and, in the case of the horizontal plane, by comparison with a spirit-level, or the lower edge of the bricklayer's plumbline and level combined.

III. The Spirit-Level.—As liquids always seek the lowest level, they run down from a higher to a lower one until all the surface is at one uniform, and that the lowest, height. This is the principle of the Spirit-level.

The instrument consists, therefore :—

(*a*) Of a closed vessel. If this were open the liquid would run out of it at the lowest end, in seeking the lowest level.

(*b*) This is nearly filled with spirit of wine, which is a mobile fluid, and one that will not rust the containing vessel or tube.

If it were quite filled, there could be no change of level in the fluid; and, therefore, of course, no visible indication of outside change of level. If it were filled to only a small extent, we should have nothing at the surface of the fluid and close to the top of the tube, which would indicate small changes of inclination from the horizontal.

(*c*) A bubble of air is left above the spirit of wine. As the latter moves about, it shifts about the former also. When the instrument is perfectly level, the surface of the fluid inside is perfectly level also; and the bubble of air remains in the centre of the instrument.

If one end of the tube be tilted, the fluid flows down to the opposite and lower end, seeking the lowest level; and the bubble of air, being light, runs up to the raised extremity. The reverse motion will, of course, send the bubble of air in the reverse direction, or to the opposite end of the tube. The air-bubble thus acts as an index of the level of the instrument, and of the surface upon which it is placed; just as the hands of a watch, clock, or weatherglass also act as an index, or indicator.

(*d*) The tube is of glass. This transparent material is necessary that the air-bubble may be seen in its movements.

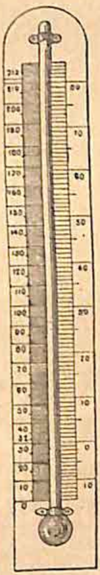
(*e*) But glass is fragile: and the instrument is required for frequent and common use. The glass tube is therefore enclosed in a brass, steel, or wooden outer case; but so that the upper surface of the glass tube inside is left visible.

IV. How Used.—(*a*) Suppose it be necessary to test the level of a mantel-piece. The spirit-level is placed on it in several places, until it is found out by the air-bubble rising at one or the other end of the tube, in which direction, if any, the mantel-piece slopes or inclines. Then the fault is corrected by raising the depressed end of the mantel-piece.

(*b*) It is also used to measure the relative heights of the ground at different points or stations. The two stations, A and B, are first made level by the use of the instrument; and a marked pole is then set up on the lower station, and another on the higher. When the "line of sight" is taken from the higher to the lower, it strikes the latter pole at a given point, the height of which is marked on it; so that the difference of height at the two stations is then a mere matter of calculation.

(*c*) It is also used to lay down tram and railway lines, in making roads, etc.

153. NOTES OF LESSONS—THE THERMOMETER.

Matter.	Method.
I. Introduction— The "*temperature*" of the air and earth varies in different *seasons*; in *day and night*; in *sunshine* and in *shade*; at different *elevations*; and at different places according to *Latitude*, or distance from the equator. Again *water* may be nearly freezing, or near the boiling point: and a piece of *iron* may be cold, red-hot, or white-hot. There are therefore various *degrees of heat*. We require something to measure these.	I. Ask children in what the difference consists between *summer* and *winter*, *day* and *night*, *sunlight* and *shadow*, the *top* and the *bottom* of a mountain, and the climate *here* and in India, or here and at the poles. This will give the meaning of the word "*temperature*", though, perhaps, the children themselves will not at first use this word. Show the class a thermometer, and explain the word as "*heat-measurer*", and refer to similar words, gas-*meter*, etc.
II. Construction of Thermometer— (*a*) We first take a *glass tube* having the same internal diameter throughout, so that equal lengths of it shall hold the same quantity of any fluid put into them. (*b*) We *melt* one end of this tube, and blow it into a *bulb*, which is then filled with *mercury*, a metal which is liquid at all ordinary temperatures.* (*c*) *Heating* the tube and its contents over a spirit lamp, the gas (air) over the mercury *expands*, rises, and escapes. Removing the lamp, the air *contracts* with the cold; and the mercury rises up the tube. We *boil* the mercury and drive out the air in it, and above it; and when this is done, melt and close or "*seal*" the upper end of the tube. We have now a roughly-made *Thermometer*, or *Heat-measurer*.	II. (*a*) Buy a little cheap glass *tubing* and some *mercury* from the chemist for the illustration of this lesson; and let the children *handle* these tubes as well as see them.  (*b*) Remind the class that we must use a *liquid* for our purpose, as a *solid* keeps the *same shape*; and we must also have a liquid that will quickly expand with heat. (*c*) In small schools where this apparatus cannot be procured, the teacher must illustrate by *drawing* it on the blackboard instead. Tell the class that water, mercury, and other *liquids* contain a certain quantity of *air* in them. We see this when we *boil* water; for the heated bubbles of air rise to the top, and we see them do so. Explain to the class that this mode of construction is too rough for actual use in making the instrument for sale, but is given for illustration only.

* Or buy this ready-made at a chemist's.

NOTES OF LESSONS—THE THERMOMETER—*Continued.*

Matter.	Method.
III. Choice of Liquid— *Mercury* is chosen for our purpose because: (*a*) It *remains liquid*, except at very low and very high temperatures; *freezing* in the former case, and passing off in a *gaseous* condition in the latter. (*b*) It *expands and contracts regularly*, with regular increases and decreases of temperature. One "degree" of heat makes it expand one "degree", as marked on the tube, with equal intervals between the degrees.	III. Tell class that sometimes *coloured water* is used instead of mercury. (*a*) When the liquid in the tube freezes, or becomes *solid*, it is of no further use for our purpose; and when it goes off into a *gaseous* state, it is also equally lost to us. (*b*) Explain that if it took three or four times as much heat to expand quicksilver at *one* time as at *another*, it would be like a foot rule that was of different lengths at different times: that is to say, the standard would not be constant, and could not be depended on.
IV. Marking the Tube— We now require a *starting* point from which to *begin* to mark off our "*degrees of heat*". (*a*) The temperature at which ice begins to melt is chosen: this is called the *freezing point*, as it is the temperature at which water begins to freeze (or ice begins to melt). We plunge our thermometer into melting *ice*, and make a mark on the tube at the point where the falling mercury remains at a constant level in this. This indicates the *freezing point* of water. (*b*) We next insert our thermometer in *steam* coming from boiling water; and mark off the point at which the expanded mercury has now risen, as the *boiling point* of water. We have now only to call the freezing point 32° (for the English thermometer, or the Fahrenheit), and choose 212° for the boiling point; and divide the 212° – 32° = 180°, between these, by equal divisions, to mark all temperatures between these extremes. Sometimes the "degrees" are marked as 0° for freezing point; and 80°, or 100°, for boiling point.	IV. (*a*)–(*b*) Remind the class that in cutting out a foot-rule from a piece of wood, the maker has to mark off a *beginning* and an *ending*. The *freezing point* is the bottom rung or round of this *ladder of heat*; and the *top* round is the *boiling point* of water. But remind the class we can make our ladder longer at both the bottom and top ends. Tell the class that we can *scratch* the marks we require on the glass by the sharp point of a *diamond*. Or we can cover the glass with wax; then scratch the marks through this, and pour an *acid* into the scratchings, which will eat or bite into the glass, and leave a mark behind. Illustrate all the points mentioned on a school *thermometer*, which can be purchased for sixpence; and draw an enlarged diagram of this on the blackboard. Accustom the children to read this, and especially to note: (1) The *Freezing Point* of water under ordinary circumstances, 32°. (2) *Temperate* heat, 55°. (3) *Blood heat*, or the heat of the human body, 98°. (4) *Boiling Point* of water under ordinary circumstances, 212°.

154. THE BAROMETER.

INTRODUCTORY SPECIMEN LESSON.

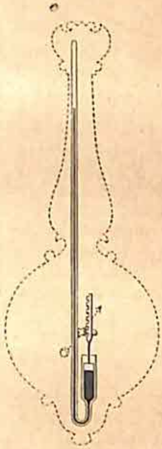
I. The Air has Weight.—That the air has weight can be proved by actually weighing it. But as the weight of the air is so light, we must do so;

(1) With delicate instruments.

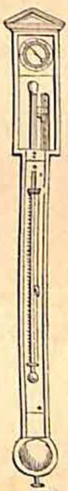
(2) We must use a very light vessel to contain it; such as a balloon of collodion, gold-beater's skin, etc.

The balance or scales used may be the Chemical Balance, employed to test the weight of the smallest possible quantities of chemicals.

That air has weight can also be proved by the experiment of the inverted tumbler of water, and sheet of paper (*vide* Part III.); the weight or pressure of the air upwards sustaining the water in the tumbler. As the latter has weight, the former must have upward pressure to sustain it; and this upward pressure is due to the weight of air pressing down on the particles of air at that spot.



Wheel Barometer—back view.



Upright Barometer.

II. This Weight Varies.—(*a*) The atmosphere is not all a pure mixture of the two gases, oxygen and nitrogen; there is always more or less watery vapour, etc., in it. The weight or pressure of the air, therefore, alters with the quantity of moisture present in it.

(*b*) Again, the pressure on the bottom of a pile of books is greater than that on the second, third, etc. So, also, at the bottom of a deep ocean, the pressure of water is greater than at only a foot, or a yard's depth: it will indeed depend on, and be in proportion to, the depth.

(*c*) Similarly, the pressure of the air at the bottom of a mountain from the greater mass of air above it, is greater than at the top; we therefore need pay attention to the weight of the atmosphere in this matter of elevation, as by it we can tell what that elevation is.

III. Need of a Weight-Measurer.—We thus see that a weight-measurer, or a barometer, is useful;

(*a*) To tell the heights of mountains, etc., above the level of the sea.

(*b*) To tell us the variable amount of moisture present in the atmosphere.

In addition, the weight of the air depends somewhat on the character and force of the wind. We therefore also use a barometer,

(*c*) To tell us something about wind.

But (*b*) and (*c*) give us indications in wind and wet, of weather, present and to come. We thus see that the barometer is useful as a weatherglass.

IV. Description of the Barometer.—As in the thermometer, the instrument includes a glass tube; but this in the barometer must now be about 33 inches high. This greater height is necessary because the air by its pressure will hold up a column of about 30 inches of mercury inside the tube. If our glass tube were of a less height than this, we should not see the top of the rising and falling column of mercury, which is to measure the greater and lesser weight of the atmosphere by its rise and fall.

There is also a vessel, dish, or cup at the bottom, likewise filled with mercury. But this is not, as in the thermometer, a closed bulb, as that would shut off the weight or pressure of the atmosphere. It is, instead, an open dish, or vessel, the mercury in which is continuous with that in the tube.

V. How Made.—First we have to fill our long tube, closed at one end, with quicksilver.

Then we invert this, and prevent the mercury from running out by closing the open end with our finger.

Next we immerse this open end into the open dish of mercury.

We might at first suppose that the quicksilver in the tube would now run out into the dish below.

It would do so if it were not for the pressure of the air on the mercury in the dish holding up this column of quicksilver in the tube with all its might. And this might is the weight of the column of 200 miles of air on the earth's surface, and on the surface of our quicksilver in the open dish, and on the 30 inches of mercury in the tube. Mercury is one of our very heaviest substances, air is one of our lightest; that is the reason why 30 inches of the one are as heavy as 200 miles of the other.

If, therefore, the air grow lighter from any cause whatever, the

quicksilver in the tube falls. The degree to which it drops is therefore a measure of the decreased weight of the air, to whatever that decrease may be due.

As the mercury drops at the top of the tube, it leaves *behind* a vacuum or empty space above it, for no air can get up there through the mercury in the tube. If there were not an empty space there, but air instead, then the pressure of this air downwards would force the mercury down the tube, and it would of course run out, and we should no longer have a barometer.

Next we have to mark our glass tube, to show the steps, as we did with the thermometer; only the marks now will be in inches and parts of an inch. At thirty inches there will be a pressure of the air of about fifteen pounds to the square inch. All the while we keep at about the level of the sea the quicksilver will rise and fall only a little above and below this 30 inches in ordinary states of the atmosphere. Of course, if we go up a mountain, and pass through one half of all the weight of the air, the mercury will drop a half of this 30 inches, or to 15 inches.

VI. A Weatherglass.—For our houses, offices, etc., we want something prettier and handier than this open dish of mercury, and its long tube. We also require some indication of what weather is to be expected from the rising and falling of the mercury in our instrument. We therefore have a Weatherglass, with a dial, or face like that of a clock. Only instead of the hours and minutes being marked on this, we have "Rain", "Fair", "Change", etc., marked on the dial plate. The "needle" that turns round, points as it does so to these words; and tells us what weather to expect. When the mercury falls it makes the needle swing round one way; when it rises it makes it do so in the other direction. So a rising and falling barometer are read, not in inches as before, but in Signs of the Weather. When the mercury falls, the hand, or pointer, turns round to the left, and points to "Rain", etc.: when it rises, the pointer turns round to the right, and opposite to "Fine", etc.

VII. Uses of the Barometer.—(*a*) To the farmer, to tell him when to sow, reap, gather in the harvest, etc.; and when not to begin to attempt to do so.

(*b*) To the mariner, especially in some seas where typhoons, storms, hurricanes, or cyclones, arise suddenly, and without other warning, in a few moments and from cloudless skies. This use of the barometer is the greatest safeguard against these sudden storms which the navigator has; and often the only one. The change

in the glass is as sudden and deep as it is in the weather outside.

SOME SIMPLE MECHANICAL APPLIANCES.

These are such as depend on "mechanical" rather than on physical principles, or those depending on the properties of matter; and specially those employed in the "Simple Machines", or "Mechanical Powers".

But it is the "appliances" themselves, or the concrete instruments, that are here dealt with: the laws of their action being reserved for a later stage.

Nor are all the simple machines here dealt with; but only those suggested in the Syllabus; viz., the Lever, and its two modifications, the Pulley, and the Wheel and Axle.

155. THE LEVER AND ITS APPLICATIONS.

SPECIAL INFORMATION FOR THE TEACHER.

I. What a Lever is.—(*a*) A lever is an inflexible bar, or rod. It must be inflexible, or it would bend, or break, in the using. As instances, we may take a crowbar, an oar, each blade of a pair of scissors or shears, a spade, etc. Besides the preceding there are the following common examples of the same kind, viz., the see-saw, the pump-handle, and the steelyard.

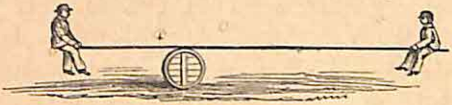
(*b*) In use it must have a weight, or resistance, to overcome; as it is employed for work. It is not kept stationary, like the support of a table, but moves about; and, in the doing so, moves also a weight or resistance. As instances of this employment, we take a stone shifted by a crowbar, water by a pump-handle, cloth cut by a pair of scissors, grass or twigs by a pair of shears, and soil lifted by a spade in digging.

(*c*) There must also be a power employed to overcome this resistance or weight: otherwise the weight would be passive, and the resistance be not overcome. As instances, we take, as in the order given before, the man's hands moving the various machines or instruments mentioned.

(*d*) There must also be a fulcrum, or resting point, on which the lever may be supported, and against which the weight and power, or the difference in amount between these two, may rest or strain. As instances, in the examples already furnished, we take a block

of wood or stone used with the crowbar, the support of the pump-handle, the rivets in the scissors and shears, and the ridge of ground in the spade.

II. Position of the Fulcrum, Power and Weight.—The four preceding items were constant, and absolutely necessary in all levers.

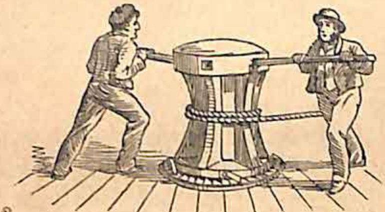


The See-saw.

But there are three other items which are variable, viz., the positions of the fulcrum, of the power, and of the weight or resistance. Each of these may be at either end, or between the extremities.

(*a*) The fulcrum may be between the power and the weight. This is the most common position of the fulcrum. The fulcrum may be anywhere between these two; in the middle, or nearer the

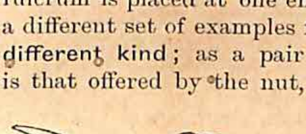
The Crowbar—First Order.



The Capstan.

weight, or nearer the power. As instances, we may take the positions in the illustrations given above.

(*b*) The weight may also occupy this relative position, whilst the fulcrum is placed at one end. As instances, we shall have to take a different set of examples from those already given, or levers of a different kind; as a pair of nut-crackers, where the resistance is that offered by the nut, placed between the power in the hand and the fulcrum at the joint. Another instance is that of a loaded wheelbarrow, where the power is applied near the ends of the handles, the weight is about the middle, and the fulcrum is the ground supporting the wheel. The human body standing on tiptoe is another example, the ground under the toes being the fulcrum; the muscular force acting on the tendon lifting up the



The Scissors.

heel, the **power**; and the **weight** of the body passing through the leg-bone falls about half-way between these.

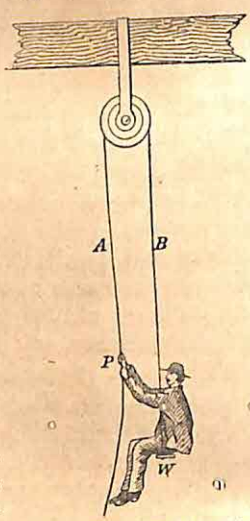
Or, the **power** may occupy this intermediate position between the fulcrum at one end, and the weight or resistance at the other. As **instances**, we may take a man raising a ladder on end by upward thrust in walking from the lighter to the heavier extremity; and a pair of tongs.

III. Single and Double Levers.—In some of the instances cited the lever was a **single** one, as in the crowbar, oar, etc. In others there were **two** connected together, or a **double lever**, as in the scissors, tongs, shears, nut-crackers, etc. But the principle is the same in both cases.

156. THE PULLEY.

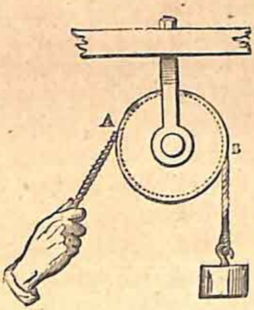
SPECIAL INFORMATION FOR THE TEACHER.

I. What a Pulley is.—This is not a **straight bar**, as in the lever; but a **round wheel**. It has, however, just the same parts as the **lever**; and we can best exemplify these on a **see-saw**, which is a form of the lever intermediate between it and its modification,—the **single fixed** pulley.



Single Fixed Pulley with Mechanical Advantage.

(*a*) In the see-saw there are **two arms**, as in all levers; but there are also two **imaginary** arms in a pulley.



A Single Fixed Pulley.

If we draw a horizontal diameter through the pulley, this represents the plank used in the see-saw, and is seen to be made up of two equal radii, which are the arms of the imaginary lever.

(*b*) There is also a **fulcrum** in the pulley at the centre. The position of this is therefore always constant, not variable as in the lever. And, of course, that means that the lengths of the arms are also always constant in relative proportion.

(c) There is also in the pulley a power and a weight, both acting through the rope: the one being the pulling force acting through a man's hand; the other, the dragging of the weight through the same rope, but in the opposite direction.

We have, therefore, in the pulley all the elements of the lever of that kind which has the fulcrum between the power and the weight.

II. Use of a Fixed Pulley.—In the lever the longer the arm at which the power acts, or—which is the same thing—the shorter the arm to which the weight is attached, the greater the advantage to the man using it. But in the single fixed pulley both arms have been just shown to be equal. There is therefore no advantage in this sense to be gained by the single fixed pulley.

But we have seen that the power and weight act in opposite directions. Now, it is more convenient for a man to stand on the ground and to pull downwards than to be on the top of a scaffold and to pull upwards. A man on the ground can use the single fixed pulley at the top of a scaffolding to change the direction of his pull in raising buckets, stones, etc., to the top of a building, with less risk than when standing on the scaffolding and pulling them up without a pulley.

If he uses a second fixed pulley, he can again alter the vertical direction of his pull to a horizontal one, and so employ a horse in raising weights too great for his own arms to lift. Thus, with one fixed pulley at the top of the scaffolding, and another just above the level of the ground, a horse can be made to draw forward in a direction parallel with the ground, and thus raise stones, etc., upwards to the top of a building.

III. The Movable Pulley.—But the fixed pulley does not give all the advantages which are to be got out of this simple machine. The fixed may be used along with the movable pulley.

In this case the fixed pulley will give as before a change of direction; but the movable pulley will also take off half the weight, whilst the other half is borne by the rope straining on the beam, or other fixed support to which it is fastened. We can understand this by the illustration of heavy weights, such as two clothes-baskets filled with linen; the one having a single handle over the top, and the other two handles, one at each side. In the first case, a person carrying this by one hand has all the weight to support. In the second instance, with two persons carrying the basket, each has to bear only one half of the weight. Here

the weight of the basket and of its contents represents the weight raised by the single movable pulley; and the arms of the bearers stand for the rope passing round this.

IV. Different Systems of Pulleys.—As the lever can be used in different ways, so pulleys may be arranged differently. It will be enough just to state this, leaving the full meaning of these to a later stage.

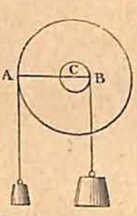
The pulley in its various combinations is very much used aboard ships to raise and let down weights, in unloading and loading cargo, and in raising and lowering masts and yards. It has the great advantage of occupying little room—and very little can be spared aboard ship—as no great length of arms is necessary as is the case in working levers. The difference in this respect can be seen in the use of the capstan, with its long levers or capstan bars, compared with the employment of a system of pulleys.

157. WHEEL AND AXLE.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—As its name implies, this consists of a wheel moving around its axis or axle; it is, indeed, the ordinary cart wheel working on its axle put to another use.

As in the pulley, it is a modification of the simple lever, with the fulcrum in the middle of the contrivance. But here the arms are not equal; for besides the axis, there is the wheel as a part of the machine to be considered.



Wheel and Axle.

There are two arms, as in the lever and pulley; and as in the pulley, one of these (the one at which the weight acts) is the radius of the axle; but the other (and the one at which the power acts), is the radius of the wheel, and therefore larger than the former. There is, therefore, always an advantage in the use of the wheel and axle; a small power always raising a great weight.

There is also the advantage, that a circular motion of a handle results in an upward pull, as in raising a bucket of water out of a deep well by a windlass. This circular motion employs different sets of muscles in the arms, and this change gives rest to some of these whilst others are working; for sometimes the handle is thrust downwards and away from the body, and at others pulled upwards and towards the body.

II. Applications of the Wheel and Axle.—The capstan is a form that comes intermediate between the lever and wheel and axle, and illustrates both simple machines very well, and in a way to be readily understood. This has either an upright axis perpendicular to the deck, or a horizontal one parallel with it.

Then there is the ordinary apparatus of this kind called the windlass used in raising water from a well. There is also the wheel at the helm of a ship, where the power is supplied and applied by the steersman's hands at the spokes of the wheel; and the weight is the resistance offered by the water to the movement of the rudder through it.

PHENOMENA OF THE EARTH.

158. SEDIMENTARY ROCKS.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—Here I mix together in this glass jar some gravel, sand, and mud, as in a previous lesson. vide P. 262

II. Application to Formation of Rocks.—(A) Comparison of sediment in glass with rocks. (1) Similarity. (*a*) From this glass jar I now pour away the water: the sediment is seen in layers at the bottom of the jar:—

1. Gravel, at the bottom.
2. Above this, coarse sand.
3. Over this, fine sand.
4. Lastly, mud.

(*b*) Certain "strata", or rock-formations, have been formed in exactly the same way. First a layer of gravel, then one of coarse sand, then one of fine sand, and lastly mud.

(2) Differences. The chief differences between the rocks and the sediment in the glass jar are:—

(*a*) Rocks are formed on a much larger scale.

(*b*) They are harder, or more "compact"; while the sediment in the glass is soft and loose.

(B) Deductions from this similarity.—(1) As the sediment and the rocks are alike in appearance, they have probably been formed in the same way, viz., by the dropping of the sediment in water.

(2) The motions of the water must then in each case have been alike, namely :—

(*a*) Rapid motion when gravel was deposited.

(*b*) Slower with the sand.

(*c*) Little or no motion when the mud was dropped down.

(C) Rock Formation.—(1) A rapid river, coming from near mountains, carries down gravel, sand, and mud; for a time the gravel is forced along the bottom, and the sand and mud are held in suspension.

(2) On entering a more level portion of the bed, a sea, or a lake, the current is checked, and the gravel dropped, the current not being strong enough to carry it further.

(3) The sand next gradually sinks at lower levels, and lastly the mud.

(4) In time the gravel deposited first partially stops up the river; so the current has its speed checked before it reaches the old mouth.

Results :—(*a*) The gravel is deposited higher up the river.

(*b*) A slower motion of the river ensues when passing over the new bed of gravel, and sand drops down on this new bed.

(5) This action is continued till the water, when reaching the first layer of gravel, has little or no motion, and the mud is dropped down. Gravel in a bed, therefore, shows that there has been a swift current there; and mud, little or no current.

III. The Sediment becomes Hard Rock.—The small grains of sand and mud are finally dropped down. Other deposits are heaped up on the first layers, till the pressure becomes so great as to bind them, and lime or iron comes in to cement the particles together.

159. THE CRUST OF THE EARTH.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—The "crust of the earth" is that part of the rocky exterior accessible to human investigation. It consists of strata of different lithological structure and texture, occurring in certain order, though many members may be here and there absent.

II. Its Form.—It makes mountain-masses, tablelands, and plains. These are to the interior of the globe what the rind is to an orange, or the crust of the loaf to the inside of it.

The undermost layers are brought to the surface by volcanic and earthquake upheaval.

This crust is the arena of all geographical phenomena, the site of the ocean, the field in which the atmospheric influences continually act, and the theatre of vegetable and animal life.

160. GEYSERS.

INTRODUCTORY SPECIMEN LESSON.

I. **What a Geyser is.**—Besides "burning mountains", there are also **hot springs**, or **geysers**, as they are termed. These look like fountains, and like them rise up to a great height in the air. They are not always "playing", however; after throwing up their waters for a short time, they cease to flow until they are ready to burst forth again. The throats of volcanoes eject **molten rock**; the throats of geysers spout up **hot water**. If, when the geyser is at rest, we throw stones down the open pipe, the water when it rises next will carry these along with it, and throw them up into the air again.

These springs are sometimes called "**boiling**", but their waters are not quite so hot as the boiling point. Some of these pillars of water are ten feet in diameter, and at times rise to nearly two hundred feet in height.

II. **Where found.**—Iceland is not the only part of the world where geysers are found; but the Icelandic geysers are the nearest to us. The word geyser in the language of the people of Iceland means "gushing". This name has been given to them from the roaring, hissing noise they make as the steam comes out of the ground, or from the mouths of the subterranean cavities where they are found.

161. VOLCANOES.

INTRODUCTORY SPECIMEN LESSON.

I. **Introduction.**—Here is a cone, used in teaching model drawing. A **volcano** at a distance often looks like this with the top of it cut off.

II. **Description.**—(*a*) **Inactive Volcanoes.**—(1) **Sides of the Mountain.** At the foot of a volcano we usually find rich vegetation; ascending, this usually gives place to huge blocks of stones, ashes, and black sheets of rock, like the slag from an iron furnace. Below this black rock, and nearer the top of the mountain, the ground sometimes feels hot, and puffs of steam and stifling gases sometimes come out.

(2) **Top of the Mountain.** What at a distance looked like a flat top is found to consist of a huge basin with steep walls. This basin-shaped cavity is the "**crater**", and the sides of the crater are formed of rough and steep cliffs. At the bottom in some recently active volcanoes we find a huge pool of liquid bubbling up like boiling water, or the whole appearing somewhat like iron in a liquid state. From this arise steam and choking gases.

(*b*) **Active Volcanoes.**—Before the volcano becomes active the whole mountain often trembles. This is followed afterseveral days by,

(1) Immense **explosions**, when the heart of the volcano may be torn open, and the upper part often blown away.

(2) Huge clouds of **steam** arise, and great masses of **rock**, stones, and cinders are blown up from the volcano. The heavier materials fall back again into the crater, or roll down the sides of the mountain. The finer ashes and dust may be forced out in such quantities as to darken the sky for miles around, and settle down on the surrounding country as a black covering.

(3) Streams of fiery or molten liquid, like melted iron, called **lava**, now flow down the mountain sides to the bottom, burning up everything they touch. Sometimes the stream does not reach the bottom; at other times it comes out in such quantities as to break down the sides of the crater and spread out over the country for many miles around the base of the mountain.

III. **Shape.**—The cone-like form of volcanoes is due to the outpouring from natural **vents** of the molten rocks of the interior of the crust. The materials are piled up in circular layers, having a **crater** in the centre or cones at the sides, from which new matter is from time to time thrown out. The mountain thus becomes cone-shaped, increasing in area at the base and in elevation.

The growth is often interrupted, however, by the upper portions of the cone becoming sapped by the heated molten masses in the crater, and by **rains** denuding the surface during the intervals between the times of volcanic activity.

The growth is **added to** by the piling up of stones, **ashes, bombs,** etc., which fall back on the outside after being thrown up from the crater.

IV. **Volcanic Order.**—The ordinary phenomena of a volcanic outbreak generally come in the **following order**; but they are rarely all met with together :—

(*a*) The centre of disturbance displays signs of an approaching outbreak by underground **rumblings**, and by the throwing out of greater or less quantities of **smoke** from the crater.

(*b*) This is succeeded by the ejection of gases.

(*c*) This is followed by the violent ejection of fine ashes, made up of the broken glassy bubbles brought to the surface of the molten lava in the crater by the rising gases, as bubbles of air are brought to the surface of boiling water.

(*d*) As the imprisoned forces gain strength heavier materials are thrown out, as stones and rocks, rising in many cases to a height of several miles, and falling back into the furnace from which they have risen, or on the slopes of the volcano.

(*e*) Meantime the molten rock or lava is sapping the walls containing it, till these can resist the pressure no longer, when it finds a vent either by some side cone, or over the broken-down edge of the crater wall, and flows on to the base of the mountain.

162. INTERNAL HEAT OF THE EARTH'S CRUST.

SPECIAL INFORMATION FOR THE TEACHER.

I. Proofs of Internal Heat.—The following common proofs are given that the earth is heated in the interior (central heat):—

(*a*) Present and extinct volcanoes, as well as earthquake phenomena, point to an intensely-heated interior.

(*b*) The increase of temperature met with in descending into the interior of the earth, at the rate of 1° Fahrt. for every 55 feet. But the actual depth attained is a mere fractional part of the whole radius of the earth.

(*c*) Thermal springs and geysers seem to imply the same conclusion as in (*a*).

(*d*) The average density of the earth is five or six times that of water. The density of all the known rocks does not exceed two or three times that of water. But the pressure of the superincumbent rocks would give a much greater relative density than five or six, unless some counteracting force were at work opposed to gravitation. We can conceive of no such influence except the expansion by heat.

But, on the other hand, the earth is not necessarily homogeneous in structure.

163. STRUCTURE OF THE EARTH'S ROCKS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Kinds.—Rocks are mostly either Stratified or Igneous.

II. Differences.—The chief points of difference between

stratified and igneous rocks relate to their mode of origin, and embrace the following special characteristics :—

(*a*) The stratified rocks, as the name imports, have been deposited in ocean, or lacustrine, areas, and often show marks of denudation; whereas the igneous show no signs of deposition, except in those cases of irregular lamination due to the piling up of igneous rocks from volcanic vents.

(*b*) The materials of the stratified rocks are more or less homogeneous in the respective kinds; the igneous are various in character in the same rock.

(*c*) The stratified contain organic remains; but no traces of such remains, if ever they existed, are met with in igneous rocks.

(*d*) The igneous rocks are distinguished from the stratified by their glassy texture, which is not to be found in any rocks formed by the action of water; they are also more frequently crystalline, and more commonly exhibit a jointed structure, often traversed by dykes from below, and by mineral veins.

(*e*) The mechanical, or aqueous, rocks comprise sandstones, limestones, and clays, or intermixtures of these, bearing marks of lamination; while the crystalline, or igneous rocks, consist of mineral masses, such as granite, etc., in which stratification is wanting.

164. IGNEOUS ROCKS.

FIRST SPECIMEN LESSON.

I. Introduction.—In a previous lesson on Volcanoes we saw the condition of the lava on its first coming out of the crater. Here is a specimen of cool lava, let us examine it.

II. Lava.—(*a*) Appearance. Carefully examining the lava specimen we notice :—

(1) Its colour may be either dark-brown or black.

(2) It has changed from a semi-liquid condition to a hard rock.

(3) It is full of little holes (porous), with here and there larger cavities.

(4) Black and white angular crystals, some very minute, and others large enough to be seen by the naked eye, are scattered through the stone.

(*b*) Cooling. (1) Changes.—The change in the lava, from liquid to solid rock, has been brought about by cooling. It comes from the crater at a white heat, flowing like molten iron. A few yards below this point it grows duller and darker just as live coal does

when it falls from the grate upon the hearth. The surface cools, and becomes so quickly solid, that in a few days we can stand on it, even where a few feet below it is still red-hot. As it cools it moves more slowly, and looks like a heap of cinder blocks, or like refuse from an iron-furnace.

(2) **Holes and Cavities.**—In a loaf of bread we see small holes formed by the steam in the dough as it was being baked. Lava was at one time in a molten state. While in that state, and still deep beneath the surface, it was full of steam and other vapours and gases. These collected into little bubbles as the molten lava rose and then they expanded and made the little holes and cavities now seen in it.

(3) **Examples.**—In the pillars of the Giant's Causeway we notice the peculiar structure of the rocks, which show that at some time volcanoes must have existed in the neighbourhood.

III. Granite and Lava Compared.—(1) In a future lesson (169, p. 334) on "What Stones tell us", we shall see that granite is composed of—

(*a*) **Felspar**, or long, smooth-faced crystals.

(*b*) **Mica**, or bright silvery crystalline plates.

(*c*) **Quartz**, or a hard, clear, glassy substance.

On examining cool lava, we also find crystal forms, some black and large, and others mere white specks. Both granite and lava are of **crystalline** formation.

(2) The substances forming **granite** appear more pressed together, one crystal being mingled with another. Lava, on the other hand, is full of holes, some of which are lined with crystals.

(3) **Conclusions from above.** From this we conclude :—

(*a*) That both rocks are of **crystalline** formation ; that they must have both been under great heat, and so turned into a liquid or pasty state ; and that both are therefore of **igneous** origin.

(*b*) That **granite** must afterwards have cooled under very great pressure of rocks above, while **lava** has cooled in the open air and without pressure of any rocks above it.

(4) During an eruption, among other things thrown out we find cinders, dust, lava and other rocks. These would be forced a great distance into the air, and would at last fall ; the larger, heavier first, and the smaller, lighter portions after. Falling in this manner the fragments would make layers. These would afterwards be pressed together, and form a hard solid rock containing irregular angular pieces.

165. IGNEOUS ROCKS.

SECOND SPECIMEN LESSON.

I. Introduction.—(1) By going back to the previous lesson on Volcanoes, we see that steam and molten rock thrown up during an eruption could only arise from great heat in the inside of the earth's crust.

(2) The lesson on Granite also told us that this must at one time have been in a half-liquid state through heat.

II. Proofs of Internal Heat.—Besides these proofs of the heat inside the earth, we find that,

(1) At the bottom of deep mines it is much hotter than at the surface.

(2) That in deep borings, when a thermometer is let down and rapidly drawn up again, the heat indicated is higher, and the water rising in the bore is sometimes warm.

(3) In our own country at Bath the water comes out of the earth at a temperature of 120°, or warmer than it is usually made in a warm bath.

(4) In Iceland, boiling water and steam come out of the earth with a great noise, and rise high into the air like fountains in geysers.

(5) The best proof of this inside heat is the volcano. Nothing but great heat could give rise to the hot vapours and steam that rise from the crater, the torrents of hot water that come from the sides, or the streams of molten lava that run down the slopes.

III. State of the Earth Inside.—From the above it is very clear that the earth inside is very hot. From experiments we find that at a certain distance below the surface the heat remains the same all the year round; but below that it rises 1° for every 55 feet in descent. If the heat continue to increase at this rate, we should find that at a depth of two miles water would be at boiling point. At a depth of 25 to 30 miles even the hardest metals would melt.

IV. The Cause of this Heat.—Ages ago the earth was like our burning sun. Since then it has been gradually cooling, and thus the heat of the crust is only now found in that part which has not yet cooled. Molten lava cools in the same way, and hardens so soon after an eruption, that at a short distance from the crater we may walk on the surface of it, while the part below this

outer crust may still be red-hot. If a lava stream be examined at the end of ten or twelve years from its coming from the crater, it is found that though its surface is perfectly cold, yet down in its inner depths the heat is so great as still to give off clouds of steam when water reaches it. If, therefore, it takes a lava stream so long to cool in its centre, we may fairly suppose that our earth must still be very hot inside, though the outer shell has been cooled for a long time.

V. Heat not felt at Surface.—The rocks forming the outside crust of the earth do not let all the heat inside pass off. They are like the outer crust of the lava stream, or like the ashes outside a live coal.

166. EARTHQUAKES.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—If we go back to a previous lesson on Air, we see that heated air expands. This is seen in a bladder placed before the fire, and from this we learn:—

(*a*) That when heated the air inside expands and occupies more space.

(*b*) That when the air inside cools, it occupies less space, and the bladder shrinks.

II. Application to Earth.—(*a*) Besides air we find that metals, and nearly all other solids, expand with heat, and shrink when cooled.

(*b*) Referring to a previous lesson we learn :—

(1) That our earth is supposed to have been once in a heated condition like the sun.

(2) That it has since cooled on the outside, and so become fit for man to live on.

(3) That the inside is still very hot, but is gradually cooling.

III. Cause of Earthquakes.—(*a*) We may conclude from the bladder that the earth, when in a molten state, took up more room than now, or that it was larger.

(*b*) We notice also that in cooling the once warm bladder shrinks first in one part and then in another.

(*c*) The same thing happens with our earth. It is gradually cooling, and therefore must still be shrinking, and so great thicknesses of its crust are broken, and moved up and down.

(*d*) These disturbances of the earth's crust we call earthquakes.

IV. Accompaniments of Earthquakes.—(*a*) If a stone be

thrown into a pond we see that waves travel from a centre where the stone falls in all directions, gradually getting lower the farther they go. So in an earthquake, the surface of the earth there rises and falls like the waves on a pond. This wave-like motion travels in all directions from the centre of the disturbance, and gets less violent the farther it goes.

(*b*) The earthquake shock is usually accompanied by noises from the ground.

(*c*) The sea often retires, and afterwards comes rushing back in immense waves.

V. Dangers of Earthquakes.—(*a*) Buildings rock to and fro like a ship at sea, and at last fall, crushing people.

(*b*) Great openings are made in the earth's crust, and houses and people are often buried.

(*c*) The waves already referred to rush in and drown people.

167. ORIGIN OF MOUNTAIN CHAINS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Secular Cooling.—The Origin of Mountain chains is to be sought in the originally heated condition of the earth. As the crust gradually cooled it contracted, and became rent, wrinkled, and cracked, as the molten interior oscillated, and the external "shell" became shrunken.

II. Water.—Again, subsequent to this, water finds an entrance to parts of the heated crust. Steam is thereby generated, and this has great explosive force.

III. Chemical Action.—Sir C. Lyell, Darwin, and others contended that the origin of mountains is to be sought in the upheaving forces generated by water coming into contact with deposits in the crust of potassium, sodium, calcium, magnesium, etc. The difficulty this theory has to overcome arises from the question whether these metals occur in sufficient abundance to account for the great force earthquakes exert. The upheavals are still going on, whether the cause be mechanical, chemical, or, as is more probable, both of these; and the results are seen in the raised beaches, etc., of the present day.

IV. Direction of Chains.—The older mountain chains were mainly parallel with each other. As the crust became more rigid in cooling, the upheavals became more violent in consequence of the greater resistance; and took effect at right angles to the former

directions. We thus get primary and secondary mountain chains, with longitudinal valleys between them, as that between the E. and W. Andes. This accounts for the higher chains being the more recent, as the Alps with late deposits high up on their flanks. These stratified deposits have been buttressed by mountains and hills, due both to upheaval and to denudation of overlying formations on the flanks of the present elevations.

(*a*) Upheaval. This agency arises from igneous or volcanic forces. The stratified deposits have thus been fractured and borne up by volcanic forces from beneath, throwing them into abrupt heights rent with chasms and ravines, either suddenly or after long periods of time in slow "crust-motions". Besides these resultant forces upheaving mountain chains and ranges of hills, we have isolated mountain masses due to the same cause.

That this has been the cause of upheaval of stratified rocks, originally deposited in horizontal layers under water, is proved by reference to the same mechanical influences at work now in the same direction. A very large portion of the earth's surface is thus either continuously or suddenly exposed to these upheaving forces. The earthquake at Lisbon was felt over an area four times as large as Europe. The cause at work is the great tension in the crust below acting in resistance to the gravity and rigidity of the stratified masses, and breaking through this resistance along certain lines, where the force withstanding the igneous agencies is weakest.

(*b*) Denudation. This arises from rivers scooping out the softer rocks on mountain sides, leaving the harder stratified rocks in chains or masses. This action is assisted by the atmospheric degrading agency of rains, and the transporting effect of marine denudation along maritime coasts. The effects of "valley-carving" are among the most important of the instances of alteration of the level of the originally horizontal strata.

This degrading action is chiefly mechanical, as illustrated by the action of rains and other atmospheric agencies, such as frost and snow, avalanches and glaciers, icebergs, marine currents, the action of tides, occasional storms and floods, etc. Thus the Ganges has not only washed down from the mountain sources of its infancy sufficient debris to make a delta of twenty thousand square miles in area, but it is also gradually spreading out this silt over the ocean floor of the Bay of Bengal.

168. STRATIFICATION OF ROCKS.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Bedding.**—The strata formed in the sea were originally soft and incoherent; they have since become consolidated by means of many agencies.

II. **Agencies.**—(*a*) **Pressure.** One of the most important agencies in the consolidation of stratified rocks is **superincumbent pressure.** This is illustrated in the artificial formation of mountain reservoirs in India by the mere deposition of the silt borne down by the torrents. These deposits have since become so consolidated in the dam thus formed, that when floods break them down large masses of **consolidated** silt are borne down without disintegration by the flood, and the walls of the rent are left standing in steep escarpments.

(*b*) **Infiltration.** Another important agency at work binding the soft incoherent masses together is the **infiltration of mineral matter,** such as the oxide of iron and carbonate of lime; and the layers of flint seen in the chalk formations in sea-washed cliffs on the south coast of England, etc.

III. **Changes.**—The **changes** undergone by the soft deposit may be thus summarized:—

(*a*) The sediment parts with much of its **moisture** when upheaved above the water.

(*b*) It **contracts** and **cracks** in drying.

(*c*) It becomes **covered over** with fresh deposits.

(*d*) Being made of different constituents, **chemical action** is induced between one and another of these.

(*e*) It is exposed to currents of **earth-magnetism,** and to great **pressure** and **heat.**

(*f*) Water percolates through it, bringing in and taking out mineral **solutions.**

169. WHAT STONES TELL US.

INTRODUCTORY SPECIMEN LESSON.

I. **Introduction.**—We can see what **classification** means by noticing the **various kinds** of books used in the school; and by the children being divided into **Classes,** or Standards.

II.—Classification of Rocks.—The word "rock" is not only used in speaking of hard materials found in the ground, such as granite, but also of such substances as mud, clay, gravel, sand, peat, etc. A rock is therefore any part of the earth's crust; or anything solid which is neither animal nor vegetable. Rocks are therefore the same as the mineral kingdom. By looking at specimens of granite, chalk, differently coloured sandstones, etc., we see that these rocks can be placed in classes just as books are.

(*a*) Sandstone. (1) If we examine a piece of sandstone we see,

(1) That it is made up of small grains.

(2) That these grains are water-worn.

(3) That they may be separated by scraping.

(4) That they are sometimes in layers running parallel with each other; and that these layers are of various thicknesses.

(5) That some particles are hard and look like glass; others are softer and glisten like silver; and some have a dull earthy look.

(6) In some rocks of this class the grains lie touching each other, but in others they are separated by a kind of cement.

(7) If we examine a piece of differently-coloured sandstone, we see that it is of the same structure as the piece just examined, although different in colour.

(*b*) Granite. If we examine a specimen of granite we notice that it is composed of minerals.

(1) Felspar, in long, smooth crystals of a pale flesh-colour, or dull white, which can with difficulty be scratched with a knife.

(2) Mica, in bright silvery glistening plates, which can be easily scratched or split. This is the same material as the silvery substance found in sandstone.

(3) Quartz. This is a hard, clear, glassy substance, on which a knife leaves no mark, and which is of the same material as most of the grains in sandstone.

(4) That the crystals are not arranged in any order, but are scattered throughout the whole specimen.

(*c*) Chalk. If I brush this chalk into a fine powder and put a little of it into a glass bottle of water, when it has stood long enough for sediment to form at the bottom I can pour the water off and examine the sediment under a microscope. Then I find:—

(1) That it is made up of very small particles of the same colour, but of very different shapes.

(2) That these consist of whole minute "shells", pieces of larger "shells", coral, sponges, and other white particles, which are the remains of the skeletons of once living creatures.

III. Conclusions from the Structure of Rocks.—(*a*) **Sandstone.** From our examination this was found to be composed of worn grains of other rocks arranged in layers.

From the fact of the grains being **worn** we conclude:—

(1) That they must have been **carried** along by a rapid stream after being broken off from other rocks;

(2) That they must have been **rubbed** against each other by streams or by the sea as we saw gravel was;

(3) And that at last they must have been **powdered** into the fine grains of sand which we now see in the sandstone rocks.

From the arrangement of these layers we conclude:—

(1) That the small grains have been carried along in a rapid stream, and then deposited where the current became slower as the river entered the sea.

(2) That sandstone, and all rocks like sandstone, are **sedimentary** rocks, or rocks laid down in water as sediment.

(*b*) **The Chalk, or Limestone, Group.** From our examination we found this was made up of broken bits of shells, coral, sponges, etc. From this we conclude that it must have been formed at the bottom of a **lake** or sea. All such rocks formed from the remains of once living animals we call **Organic Rocks.**

(*c*) **The Granite Group.** From the structure of granite we see:—

(1) That it is composed of **three** distinct **crystalline** materials.

(2) That these crystals do not occur in any order, but are **scattered** throughout the mass, or are confusedly mixed.

We therefore also conclude:—

(1) That these minerals composing the granite must have been subjected to sufficient **heat** to bring them to a **fluid** or **pasty** state;

(2) That the newly formed pasty rock then **cooled**;

(3) That there must have been very great **pressure** upon the rock when heated and when cooling;

(4) And, therefore, that the formation of granite must have taken place **deep** down in the crust of the earth.

To all such rocks, formed by the aid of heat, we give the name of **Igneous Rocks.**

170. FOSSILS.

SPECIAL INFORMATION FOR THE TEACHER.

I. What they are.—**Fossils** are geological evidences of pre-existent animal or vegetable life. They include the **remains** of animals or vegetables, as well as the **footprints** of the former,

and impressions, and casts of both. They do not belong to the present fauna or flora of the globe, though in many instances they are closely related to these, but they are to be referred to the province of Palæontology.

II. Their Interpretation.—Fossils are records of the dead past inscribed on the strata of the earth. They are like an interrupted series of volumes of the history of the earth's changes. Of these volumes many chapters and pages are missing; and the language has been undergoing constant changes, so that fossils mark the age and history of the formations in which they severally occur. Or the earth's crust may be said to be like a museum in which are arranged the various types of a former life, in a gradual but often interrupted chain of development.

Sometimes certain fossils are peculiar to a particular formation. They are then of great value to the miner, who would not think, for instance, of sinking for coal in a place where certain fossil fishes were found, since these did not appear on the earth until later than the coal deposits.

III. How left.—Fossil shells become enclosed in rocks by,

(*a*) Deposition in ocean and lacustrine areas, as seen at the present time in the ooze of deep-sea soundings.

(*b*) By drifting of sand at high water over deposits made at ebb tide.

(*c*) By the sudden or gradual lowering of riverine and oceanic margins containing shells.

(*d*) By the covering of the deposits of kitchen-middens (banks of shells of shellfish eaten by prehistoric man), as seen on the shores of the Baltic.

(*e*) By the drifting of sands in dunes on sea-coasts.

(*f*) By the irruption of the ocean into low-lying districts, as in Holland.

171. THE OCEAN: ITS DEPTHS.

INTRODUCTORY SPECIMEN LESSON.

I. The Sea Bottom.—The floor of the ocean is an exact counterpart of the surface of the continents, having the same differences of height, in valleys and mountain-chains, plains and table-lands; but covered over with sediment, as the dry land is with soil. This follows from the fact that the floors of the oceans of to-day were formerly the continents. This alteration of level has been brought about by the vast changes that have taken place

in the situation of land and water under opposed earthquake and aqueous agents.

II. Line of Greatest Depth.—As the continents have a slope and a counterslope, so, generally, the shores of the oceans slope out towards a trough, or valley, of greatest depth. Those seas which have the most gradually sloping shores are generally the shallowest in depth. The slope is carried on beneath the surface of the water, in continuation of that of the land. This generally enables us to form a notion of the position of the trough of greatest depression and of the amount of its greatest depth. Thus, if the counterslopes of two continents on opposite sides of an ocean be continued until the lines meet at an angle, the position of this crossing of the lines will give a general notion of the probable situation of the greatest depth beneath it.

III. Extreme Depths.—Experiments which have given such great depths as 46,000 feet in the South Atlantic may be open to suspicion, as the sounding-lines—though this is not necessarily the case—may have been bent aside by currents. At great depths the weight of water would be increased, and the difference between this and that of the lead used in sounding would not be so great as at the surface, so that a less force would bend the sounding-line out of the vertical.

IV. The Atlantic Plain.—A section of the Atlantic Ocean, taken along the line of the Atlantic cable, shows that for the first 230 miles from Valentia to the west there is a fall of only 1 ft. in 1,000. In the next 20 miles, by a succession of rapid falls, the bottom further sinks to 9,000 feet, and preserves the depth thus reached for a length of 1,200 miles along the great "Atlantic Plain." From this plain a natural causeway leads up to the coast of North America, having on either side of it an extreme depth of 30,000 feet. This is the elevated line of route along which the Atlantic telegraph has been laid.

172. OCEANIC CIRCULATION.

INTRODUCTORY SPECIMEN LESSON.

I. Hot Water rises.—In heating a house by hot-water pipes, we have a cistern below heated by fires. From this, pipes are conducted to the upper chambers, and these return again to the cistern. The water in the cistern heated by the furnace becomes expanded, and therefore lighter, by the heat. It therefore rises up the pipes.

But as soon as in a circuit we set up a circulation, this will be continued throughout that circuit. Colder water, therefore, has to come down through the **descending** pipes to make up for the warmer, lighter, and therefore rising water which has flowed from the cistern up the **ascending** pipes. This water, as it again becomes heated at the cistern, and afterwards cooled in the upper part of the pipes, once more returns into the circuit.

II. **Application.**—The same thing holds good in the great **ocean** areas. The air over the **poles** makes the water there cold and heavy; it therefore sinks to the bottom. Other water flows in to fill up its place, and this can only come finally from the **equator.**

III. **Effects.**—The **effect** of this circulation of the water of the ocean is to take the surface waters, holding oxygen in solution from the air, to the lowest depths. It is thus that the marine **animals** living at the greatest depths are kept supplied with **oxygen** to purify their blood. Without this circulation oxygen could not reach the lowest depths of water, and animal life would therefore cease to exist there. We thus find animal life in the greatest depths of the oceans; but in enclosed areas, such as the Mediterranean Sea, where this circulation does not exist, there is but little animal life at great depths.

It is by means of these currents of cold water from the poles that Arctic animal life is transported thousands of miles from the poles to warmer latitudes. The existence of cold **deep** streams pouring from the Arctic basins towards the equator is proved by the rounded outline of the pebbles at the bottom, showing the action of running water.

But beneath the **shallow** warm waters of the deep Atlantic we have the chalk ooze, made up of the "shells" or tests of animals, which, as they died, sank to a quiet resting-place undisturbed by the action of running water.

The oceanic circulation is the cause of the **milder** climates enjoyed by the western shore-lines of the great continents of the Old and New World, compared with the **colder** climates of the eastern shore-lines.

173. MOVEMENTS OF THE OCEAN.

INTRODUCTORY SPECIMEN LESSON.

I. The **Motions** of the waters of the ocean are,

(*a*) **Superficial** and **temporary**; such as waves raised by winds and storms striking on the surface of the waters at an angle. This

motion extends only to a slight depth, but spreads over a large surface, becoming weakened as it spreads from the centre of disturbance.

(*b*) **Deep and constant**; as in the case of marine currents due to the different densities of water at different parts of the earth's surface. The cold heavy waters at the poles sinking downwards cause an indraught or horizontal flow to keep up the level of the water there.

(*c*) **Periodical**; these affect large masses of water, as in the case of tidal waves.

II. Detail.—(*a*) **Surface Waves.** As wind-waves arise from the pressure of the air against the easily-moved particles of water, the height of the waves depends on the violence and direction of the wind. In a severe storm there may be a pressure of air of 45 lbs. to a square foot. If this were directed level with the surface of the water, it would only make a surface current in its own direction. If it flowed at right angles with the water—as is so often the case for a short time in the most violent tempests—it would allay rather than create a disturbance. But when the wind strikes the water at an angle between the horizontal and vertical, we have a ridge raised up, which, from crest to trough, sometimes measures in the open ocean as much as forty feet in vertical height.

If these waves are dammed up, as in the water of narrow channels, straits, and inland seas, we may have an extreme height of a hundred feet. The particles of water give way at once to any force pressing upon them, as they are not like solids, but perfectly movable among each other. The disturbance does not reach very deep down, and at a depth of three hundred feet all is unruffled calm.

(*b*) **Salt Water.** This, as it becomes colder to 25° F., **contracts** in obedience to the usual law, from which point it **expands** under greater cold, in opposition to the usual law at this temperature.

(*c*) **Polar Underflow.** The water round the poles is colder and heavier than that at the equator. It therefore presses out sideways, causing an outflow from the polar basins of the deeper water along the deep ocean channels towards the equator. This makes the waters of the ocean as they pass southwards colder than they would otherwise be; so that if we sound deep enough we shall always find water near 32° F., or freezing point, even under the equator.

(*d*) **Equatorial Inflow.** This outflow from beneath must be supplied by a surface **inflow** from the equator to the poles, bringing

in the warmer, lighter water. This in turn gradually becomes again colder and heavier, sinks, and thus keeps up this vertical circulation. As this inflow from the equator in its passage towards the poles becomes colder, and at last from its greater density sinks to the bottom, so the polar currents from the poles to the equator become heated by the ocean-bed and by the warmer waters above. They thus become lighter, and rise to the surface, and so keep up the constant vertical circulation.

174. THE AIR.

INTRODUCTORY SPECIMEN LESSON.

I. **Air a Substance.**—(*a*) When we wave our hand, fan ourselves, run, or put our head out of a train in motion, we feel something resists us.

(*b*) If we try to force an inverted glass under water, something prevents the water from rising to the top of the glass.

(*c*) That "something" felt in the above experiments is air.

(*d*) Air, therefore, is everywhere round the earth, as our experiments everywhere give the same results. We breathe it, feel it, but cannot see it. But there are many other substances that we cannot see, such as other gases, hydrogen, oxygen, etc.

II. **Air is Compressible.**—(*a*) The glass I have already referred to was full of air, but when I inverted it, the water forced its way up only a short distance into the glass.

(*b*) The air inside could not come out to make room for the water to come in, as the water below served as a plug or a cork.

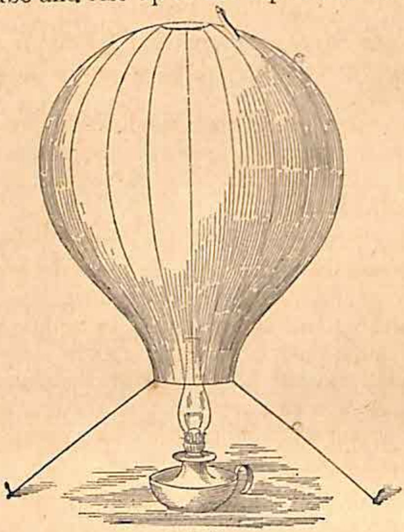
(*c*) The small particles of air in the inverted glass must, therefore, have been pressed closer together. I will illustrate this by filling this bag with bran, now pressing it down, and getting in more bran by pressing the small particles closer together.

III. **Air is elastic.**—(*a*) These particles of air can not only be pressed together, but they can also be separated, or driven further apart, and made to occupy more space.

(*b*) I take this child's toy bladder, tie up its neck, and place it near the fire; now the sides swell out or expand, not by more air rushing in, for the neck is tied up, but by the air inside being made to occupy more room as it becomes heated.

(*c*) The fire balloon acts in the same way by the heat from the lighted material at the bottom causing the air in it to expand and become lighter, and to press upwards against the top of the balloon.

(*d*) I place this glass tube partly in water, and hold a part in my hand out of the water. Bubbles are now seen to come from the tube and rise up to the top of the water. These are caused by the air in the tube expanding from the heat of the hand, and forcing its way out through the water. This separation of the particles of air has been caused by the heat.



Air Balloon.

IV. Results of the Experiments.—(*a*) Going back to the toy bladder, you saw that when expanded by heat I had some little difficulty to hold it. It wanted to rise.

(*b*) The air and fire balloon rose when it was expanded by heated air.

(*c*) Now we know that the reason why iron sinks and cork rises in water is because iron is heavier and cork lighter than water

From all these things we learn :—

(1) That **heat expands air**, and makes the same quantity occupy a greater space.

(2) That heated air is **lighter** than cold air, and therefore rises.

V. Weight of Air.—(*a*) **Proof of weight.** Here is a vessel full of air. Now I remove the air from its inside by means of the air-pump. The sides of the vessel are weak and are forced in, and this could only be caused by the weight of the air outside. Now I will give you what this weight is, viz., 15 lbs. to the square inch.

(*b*) **Air presses equally in all directions.** (1) By finding out how many square inches of surface there are in a man's body we find that the actual weight of air on a man is several tons; and yet we can feel no great weight on ourselves. This is because the weight is pressing on him in all directions.

(2) I now fill a glass with water, cover its mouth with paper; and, with my hand held firmly on the paper, invert it; on removing my hand from the paper, you see the water does not flow out.

Therefore, air presses upwards with a greater force even than the water presses downwards.

(3) Anything lighter than air therefore rises, because the air floats it up.

VI. Air Currents.—Results of expansion. (*a*) When air is heated in an open vessel there is less air in a given space in it than before.

(1) This can be seen from my experiment with the heated bottle or tube; for when cold the bottle was full of air, but by heating it some of this was forced out. There must therefore be less left in it afterwards than there was at first.

(2) It may also be seen that there is less air in the heated tube, by my removing the lamp or my hand, forcing the tube deeper into the water (thereby cooling the air inside), and then again raising it. The water in the tube, you now see, rises to a higher level than that outside.

(*b*) The second result is that heated air is lighter than the surrounding air, and therefore rises.

(1) This may be seen when I puff smoke near the flame of this lamp: the smoke rises with the heated air over the flame.

(2) You also see the same thing when I place a piece of down over the lighted lamp; the down rises at once.

(*c*) Formation of Currents. The place of the heated air is filled up immediately by colder air rushing to the lamp. This in turns gets heated, rises, and other cold air fills up its place. If this cold air did not take the place of the risen air the candle would not burn. You see this when I put this lighted candle inside this bottle.

(1) I put a cork in the bottle and the light goes out, because the candle consumes all the oxygen, and no fresh supply can get in.

(2) Next I insert two tubes a short way through the cork into the bottle, and still the candle goes out, because the heated air rises and escapes through the tubes, and so prevents a fresh supply from getting in.

(3) Now I push one of the tubes to the bottom. Then the candle burns, because the heated air rises and escapes through the tube at the top, and the colder air rushes in by the other tube to the bottom, and so gives the candle a fresh supply of oxygen.

VII. Winds.—Differences in temperature.

(*a*) The heat in one day varies. The heat is not so great at sunrise and sunset as at mid-day, and the causes for this are: At mid-day the sun is almost over our heads, and his rays almost

vertical; at sunrise and sunset the rays are slanting (oblique), and at last horizontal. From this variation of heat we get land and sea breezes.

I have already shown you by an experiment that vertical heat is greater than slanting heat, by setting a boy in front of, and at the side of, a fire.

(*b*) **The heat on the earth varies.** Since the sun is sometimes directly over the equator, and at others north or south of it, the tropics must receive the sun's rays vertically, while parts north or south of the tropics must receive them slantingly. The slant is greater the further we travel north or south of the equator, and greatest at the north and south poles, where it becomes horizontal.

(*c*) **The result of unequal distribution of heat.** (1) The earth near the equator receiving the **vertical** rays of the sun is hottest.

(2) This heated earth heats the air above it, and causes it to expand, become lighter and rise.

(3) Heavier air from colder parts of the earth, north and south of the equator, rushes in, to become in its turn heated and to rise.

(4) There is therefore a continuous stream of cold air setting from the north and south to the equator, causing thereby winds from these directions.

175. NATURAL PHENOMENA: THE AIR.

NOTES OF LESSONS—AIR AND WINDS.

Apparatus.—Test tube, lamp, paper, and tumbler of water.

Matter.	Method.
I. Introduction— The air is *invisible*, and therefore we are at first unaware of its existence. But it is a *substance*, for it can be *weighed*; we can also feel it *resisting motion*, and can *remove* it, *compress* it, etc. It clothes the earth like an *ocean*, only much less dense than water, but of much greater depth (or height), about 200 miles. So there is air higher than any mountain, and above any distance a balloon can ascend. It travels with the earth in the latter's path round the sun.	I. Remind the class that we have *senses* (sight, hearing, taste, smell, touch); and that we tell the properties of *matter*, or the things in the world around us, by one or more of these. We cannot see, hear, taste, nor smell air, but we can tell there is such a thing by *touch* or *feeling*, when we wave our hand through it, or when it blows against us as *wind*, which *is air in motion*. Draw a diagram of the earth, and its ocean of air around it.

NOTES OF LESSONS—AIR AND WINDS—*Continued.*

Matter.	Method.
II. Properties— (1) It is *invisible*, except seen through great thickness, when it has a bluish tinge, as when viewed also through a long *pipe*; when looked at upwards against the background of the *sky*; and when turned by pressure and cold into a *liquid* state. (2) It can be pressed close together, and afterwards comes back to its former size. That is to say, it is *elastic*, taking up less bulk or size under *pressure* and *cold*, but rebounding with heat, or when the pressure is removed. The sun heats it, and makes it lighter, so that it expands and rises; the cold of the upper air again condenses it. (3) It *supports life*. Animals without it die of suffocation. Plants also require it. (4) It has *weight* (15 lbs. to the square inch): and as it is so deep, its total weight is very great. (5) This weight, or pressure, acts in *all directions*, upwards as well as downwards. *Solids* press only downwards; and *liquids* downwards and sideways, not upwards at the surface, though they do so below the surface. In this respect air is like all other gases.	II. (1) Remind class that *properties* are the things by which we know anything about substances, as told by our *senses*, and our *sense*, or reason. Tell children that a great chemist is now able to turn air into a *liquid* form like water. (2) Illustrate this property by *squeezing* and *relaxing* sponge, wool, and india-rubber; also explain the action of the pop-gun and syringe, depending on this property. In both cases the air is compressed, and in both it shows how *elastic* it is by forcing its way out. Illustrate the sun's action by a partially inflated toy *air balloon* swelling up before the fire. (3) Ask what happens when people are shut up in such places as the Black Hole of Calcutta, etc. (They die of *suffocation*.) (4) *Calculate* on blackboard what this amounts to on a sq. foot of surface. (5) Illustrate by *cork* rising from bottom of water; air bubbles of carbonic acid in soda water, rising upwards from water; and by a sheet of paper over an inverted glass of water pressing the water up, and sustaining it.
III. Winds— (*a*) *Heat makes air rise*, whether the heat be above the air as with the sun shining, or below it as in a fire. (*b*) *Cold air descends*; hence cold draughts along the floor to feed the fire; from mountain-tops to neighbouring valleys, or to mountain lakes, giving rise in the latter to sudden storms. (*c*) There can naturally be no open space *without air*. If, therefore, heated air rises, colder air *must* come in to fill its place. This makes a *draught*, or wind. So wind is "air in motion".	III. (*a*) Illustrate by letting a light *feather* rise up the chimney over a fire, or over a lighted lamp with tall glass chimney. (*b*) Illustrate by open *window* and child sitting beneath it; and by candle flame blown inwards beneath the door of the schoolroom. Refer to the sudden storm on the Lake of Galilee mentioned in the New Testament. (*c*) Squeeze out all the air in a toy "squeaker" (air balloon): then open its mouth, and let class see how something rushes in to *inflate* it again; there is nothing to do this except the air in the room.

NOTES OF LESSONS—AIR AND WINDS—*Continued.*

Matter.	Method.
IV. Balloons— These may be made of paper, silk, or other *light* material. They are filled with a gas lighter than air, such as *coal gas*, or with warmed air. A toy balloon ("squeaker") filled with warm air from *the lungs* will rise, as a *soap-bubble* does, and for the same reason: the heavier air outside buoys or presses it upwards.	IV. Fill a *balloon* made of thin (and therefore very light) *goldbeater's skin* with *hydrogen* (the lightest gas known). This when released rapidly rises to the ceiling, even when loaded with a small weight. Let child blow some *soap-bubbles* before the class, and explain the properties of these.
Or the balloon may have a car or basket at the bottom, with a *fire* in it. The fire will make the air over it *lighter*, and the light air will then inflate the balloon, and it will *rise*, pushed up by the colder, heavier air outside, as a cork does in water. As the air inside the balloon *cools* when the fire or light beneath goes out, the balloon slowly *descends*.	Tell the children that the first balloons made were *fire-balloons*, or those heated by a fire. These may be bought at toy shops, and one or two should be used to illustrate the lesson. Tell the class that *air* stands for, or represents, all other gases; but that really it is itself a *mixture* of two gases, each of which has been turned into a liquid state by cold, as the air itself also has.

176. MOISTURE IN AIR.

INTRODUCTORY SPECIMEN LESSON.

A. Evaporation. I. Introduction.—If we make water boil in a kettle, we see,

(*a*) That steam comes out of the kettle as long as the water boils.

(*b*) That as the steam comes out, the water in the kettle becomes less and less; and, if the kettle be not re-filled, all boils away, and the kettle is left dry.

(*c*) That it is heat that thus changes the water into steam.

(*d*) That at the spout, and a very short distance from it, the steam is invisible.

II. Application to Evaporation.—(*a*) This disappearance is due to the water being taken up by the air into itself. It has been taken by the air just as really as blotting-paper soaks up ink, but not in the same way.

(*b*) This moisture, or vapour, although invisible, is still in the air, just as the ink is in the blotting-paper, or as sugar and salt are in water when dissolved, although invisible.

(c) This changing of water into vapour, and its passing off in an invisible form into the air, is continually going on, thus :—

(1) If water be placed in the open air, it gradually lessens, and at last disappears.

(2) Wet clothes on a line lose their moisture.

(3) Puddles in the street gradually disappear, and the wet road becomes quite dry.

This disappearance of the water from the basin, clothes, and road is due to the air taking it up in the form of invisible vapour. This action we call evaporation.

III. The Rate of Evaporation Varies.—(a) In summer, the above changes take place more quickly than in winter.

(b) The same is true on a warm, more than on a cold day ; in fine, more than in damp weather.

(c) Hence we conclude that, (1) Warm air takes up vapour more readily than cold, and can hold more of it.

(2) That there is greater evaporation during the day than at night, and in summer than in winter.

(3) That there is more evaporation in dry, than in wet, weather.

B. Condensation. I. Introduction.—From the previous experiments we see that, if the temperature be lowered, the air is unable to hold as much vapour as before ; and therefore gives up part of it in some form or other.

II. The Idea of Condensation Worked Out.—(1) Examples. (a) In a person breathing on a warm day, the breath is invisible, but on a cold day it is visible.

(b) At the spout of a boiling kettle nothing is seen, but at a short distance from it we see steam.

(c) On the windows of a very hot room we see "mist" (like dew).

(d) Mist is also found on the outside of a glass of cold water when brought into a warm room.

(2) Cause of these Changes. In each of the above cases, warm air, with its invisible vapour, has been brought into contact with something colder ; its temperature, therefore, has been lowered. The power of holding as much vapour as before has also been lessened. The air must therefore give up some of its moisture, and the invisible vapour is changed into mist. This mist, if kept in contact with the cold substance, undergoes another change and becomes water.

This changing from invisible vapour to mist, and from mist to water, is called condensation.

Condensation is therefore the changing of invisible vapour to visible mist and water, by lowering of the temperature.

III. Application to the Formation of Dew.—(*a*) **Radiation.** After sunset the earth's surface rapidly gives off the heat stored up in it during the day, until it is at last colder than the layer of air just above it.

(*b*) **Effect upon Air.** This layer of air, being cooled, can no longer hold so much vapour in an invisible form as before. It therefore parts with it, in the form of a visible mist. This mist consists of very small particles of water. It is the running together of these particles which makes the larger drops found as **dew** on grass, leaves, flowers, etc., at night.

(*c*) **Clouds and Rain.**—(1) **Clouds. Condensation in air.**—We have seen that as air becomes heated it gets lighter and rises. When risen, the heated air comes into contact with colder currents, and is itself made colder. It cannot therefore hold so much invisible vapour as before, and is obliged to part with it in the form of mist or clouds. Clouds, therefore, are formed by the condensation of moisture in the air.

(2) **Rain.** As the condensation continues the clouds get thicker and darker. The mist on the glass, and the cloud in the sky, are both formed of very small particles of water. In the one case, the water trickles down the glass; but in the cloud, the small particles grow bigger, until they form **drops** too heavy to hang together in air. They then fall as **raindrops.**

177. DEW.

SPECIAL INFORMATION FOR THE TEACHER.

I. What Dew is.—When the air has become **saturated** from the sun's evaporation of water during the day; and the surface of the earth has been rapidly **cooled** by radiation during the night,—the vapour in the film of air over the cooled surface of the earth becomes **condensed.** This air is thus no longer able to hold in suspension all the aqueous moisture it held before during the day. Some of this is therefore deposited in minute **vesicles** upon the surface of the earth, and especially upon **non-conducting surfaces** which cannot bring up heat from the earth, such as grass, foliage, etc.

II. Checks.—The circumstances which **interfere** with the formation of dew are:—

(1) A small diurnal temperature;—preventing much evaporation, and saturation of the atmosphere.

(2) High temperature at night;—preventing rapid cooling of the earth's surface.

(3) Strong winds;—mixing the warm air above the surface with the cooler film of air over it.

(4) Much cloud;—sending back or reflecting to the surface the heat radiated.

(5) Absence of bodies of water;—from which evaporation in the daytime could take place.

178. DEW.

INTRODUCTORY SPECIMEN LESSON.

I. **Introduction.**—We become so used to many things that we do not at last take any notice of them; and yet, in most cases, we do not understand after all what is so common. I dare say every one in this class thinks he knows what dew is; yet there is not perhaps a single child that really knows what is the cause of dew. Let us, therefore, try to find this out; then the next time we see the grass or twigs gemmed with tiny drops of dew—sparkling like glass beads in a necklace—we shall think more about the dew than we do now.

II. **What Dew is Made of.**—In the first place, dew is water;—that is plain enough. The question arises, where did it come from?—out of the air, out of the ground, or out of the plants? Not alone out of the plants, for we find it—though not so much of it—on the garden roller, on the pebbles, on the walks, and on posts and rails. And not out of the ground, for we find it even when the ground underneath is quite dry. It must then have been in the air.

If so, it is not hard to understand how it first came there. For we know the sun is shining during the day, and drying up, or turning into vapour, much water from the damp ground and from the surfaces of rivers, ponds, and lakes. It is for this reason that the air always has moisture or vapour in it except over a few deserts.

III. **How Found.**—The next question is, then, why did the moisture drop down as dew?

(*a*) First, dew falls at night; so that must have something to do with it. The great difference between day and night is, that the

one is light and the other dark. But this has nothing to do with the forming of dew; for if we take a glass of cold water into a warm lighted room, the outside of the glass is soon covered with a kind of dew. And exactly the same thing takes place if we take the same glass into a warm dark room.

(*b*) Another difference between night and day is, that one is warmer than the other. Perhaps, then, the coldness of the night has something to do with the dropping of the dew.

If we place our hand on the ground when the sun is shining on it, we feel the ground is warm to the touch. If we do the same at night, we feel that it is cold. This gives us the cause of the formation of dew. The earth's surface at night is like the cold glass taken into the warm room. The cold body chills the air all around it; and then the moisture in the air drops down as dew, both on the glass and on the earth.

IV. When Formed.—We do not find dew on the ground all the year round, nor in the middle of the day. In winter time it becomes frozen on the window panes, grass, and twigs of trees.

We want warm days, that there may be plenty of moisture taken up by the sun; and cold nights, that the earth's surface may soon get cold, to chill the air above it. Thus we have most dew on still, quiet nights; so a dewy night is a pleasant one. If there is much wind the air is blown about, and the cold air just over the earth's surface gets mixed up with the warmer air all around. Then the moisture is not chilled out of it into drops of dew.

V. In Hot Countries.—In countries where but little rain falls the dew is more highly prized than with us. Very often it falls there more heavily than with us. It is there the chief source from which plants become refreshed after the great heat of the glowing sun during the day. In such countries the dew is not only a blessing, but it is felt to be such.

VI. Cloudy Nights.—We do not have dewy nights when there are thick clouds overhead; but when it is clear and starlight. If there be clouds overhead, they send back the heat which the earth's surface on cooling gives out, just as a piece of bright tin near a lamp sends back, or reflects, as we say, the light falling on it.

VII. Conductors.—The dew does not fall on every object alike. Those objects which most require it get most of it, though not, of course, for that reason. Grass and leaves of trees are quite heavy and drooping with dew, while roads, paths, rocks, and walls have little on them. The former are bad conductors of heat, so soon get chilled. They do not draw up into them any heat again

from the earth. So they chill the moist air around them, and make the moisture in it fall as dew. The latter are good conductors, and so do not become rapidly cooled, as they are supplied with fresh heat from the ground.

VIII. Dew on Gossamer.—In the autumn, after the corn is cut, we sometimes notice that the roads and paths between hedges are crossed by thousands of fine cobwebs. These are spun by a spider, which may be seen at its work, floating in the air at the end of a thread of its own spinning. In the evening, these cobwebs act like nets set to catch the dew-beads as they fall. In the morning, when the sun shines early, and just before it has heat enough to dry up these dew-drops, it is a pretty sight to see this lace gemmed with beads.

The air is at all times more or less highly charged or filled with vapour, visible or invisible. The amount depends on the temperature; so when a cold current of air, or the cold elevated peaks of mountains, or the edges of table-lands, lower the temperature of warmer, moist air, the moisture is condensed into minute bubbles, which run together into rain as they fall. In the same way, but to a less extent, cold objects chill moist air, and cause dew.

179. SNOW, HAIL, AND ICE.

INTRODUCTORY SPECIMEN LESSON.

I. Introduction.—In a previous lesson on Condensation we saw :—

(*a*) That the higher we rise, the colder the air becomes.

(*b*) That air in rising to these colder regions gives up some of its vapour, which forms clouds.

(*c*) That most clouds consist of very small particles of water.

II. Snow.—(*a*) Formation. The cold is so great in the higher parts of the atmosphere that the small particles of water forming the clouds freeze, and the frozen particles coming together fall to the earth as snow.

(*b*) Appearance.—(1) Colour. A snow-flake is white; but water, from which it is formed, is colourless.

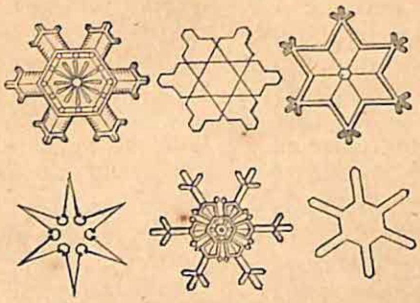
(*a*) Being white, it is very like the colour of foam.

(*b*) It is also like what is called "steam".

Both foam and "steam" have been formed from colourless water. Their particles, however, have been separated ; and so have also become mixed with air. The same thing happens with snow. The

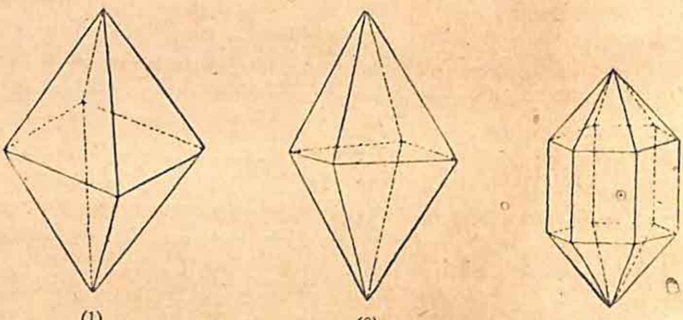
small particles of water forming the clouds are mixed with air ; and it is air in the snow which partly gives it its white colour. If we should press out all this air, the snow would then be seen as clear and as transparent as ice.

(2) **Shape of the Flakes.** If we examine with a magnifying glass a snowflake on any black surface, we see that it is formed of six little needles or **ice-crystals.** It is therefore a six-sided figure. When large numbers of flakes are viewed together, they seem, under the naked eye, to be a fine powder.



(3) **Perpetual Snow.**—(*a*) **At the Poles.** But for heat, the snow would remain as snow where it had fallen. This really happens at the North and South Poles where there is very little heat from the sun, so that all the winter's fall of snow cannot be melted in the following summer. In these places, therefore, snow lies unmelted at the sea-level all the year round.

(*b*) **On Mountains.** In the previous lessons on Clouds we saw that the higher we ascend the colder it becomes. We can therefore ascend some mountains till it is as cold on the top as at the



(1) (2) (3)

(1) (2) Octohedral Crystals ; (3) Crystals of Hexagonal System

poles. Here therefore the snow also remains all the year round, because there is not enough heat to thaw it.

III. **How Snow Disappears from Mountains.**—As the snow on these high summits never melts, it would seem that at last

the mountains would be simply buried, and would lose their shape as the hollows became filled up. This we know is not so since the snow disappears, being **pushed down** the sloping sides by the great weight of snow above to lower and therefore warmer parts, where it **melts** and often forms **rivers**.

IV. Hail.—(*a*) **Formation.** In the lesson on Condensation we learnt about the formation of rain-drops. We have different layers of the air with different temperatures, some warmer and some colder. The rain in falling therefore may pass through air so cold as to freeze it; this frozen rain we term **hail.**

(*b*) **Appearance.** Hail looks like rounded frozen particles, some larger than others; but others are less regular than this in shape. This is due to the wind driving two or three together, and causing them to join together by freezing.

V. **Ice.**—(*a*) **Formation.** Ice is caused by the temperature being so low as to freeze particles of water into a solid form.

(*b*) **Appearance.**—These solid particles fasten together, and form one large mass. It is **colourless** in small quantities, **greenish** in large, and **white** when pounded. It is **transparent.**

(*c*) **Peculiarities.**—(1) **Expansion.** Ice takes up more room than when in the liquid form as water. When water begins to freeze it expands. Hence the breaking of water-pipes during a frost.

(2) **Hardness.** We notice the softness of a pillow filled with feathers, and the apparent hardness when a larger quantity of feathers is put into the same space. The hardness of ice is likewise due to a greater number of particles in the same space, these taking different crystal forms. When melted, a given bulk of ice gives more water than the same bulk of snow.

180. ORIGIN OF ICEBERGS AND ICE.

SPECIAL INFORMATION FOR THE TEACHER.

I. **Conditions of Formation.**—**Icebergs** are formed like **glaciers**; but on less precipitous mountain-flanks, and in **colder** regions, where the snow-line is at the level of the sea. The snows that have accumulated in the polar regions on the surface of the land become pressed forward and downward from the increasing pressure, or weight, on the mountain sides, until the ice thereby formed is pushed out to the confines of the land, and floats on the surface of the adjoining sea. This becomes broken off in violent

storms, and by the rise and fall of the tides, and is carried by the polar currents towards the equator.

Icebergs can only be formed in **high** northern or southern latitudes, where there are extensive tablelands of sufficient elevation to be above the line of perpetual snow, as in the northern part of Greenland, Spitzbergen, in Nova Zembla, and Iceland.

II. Mode of Formation.—Here the snow becomes converted into **névé** and glacier ice, and, under the accumulating pressure, motion towards the sea and lower levels ensues. This is not much impeded by inequalities of surface between the tableland and the ocean, as the valleys become filled up by the accumulations of ice, leaving a comparatively level surface over which the moving ice-masses may pass on.

III. Ground Ice.—The congelation of rivers begins at the bottom; cakes of ice coming from the bottom, and sometimes bearing up with them stones and gravel.

This formation of **ground ice** may be thus explained:—The whole stream of running water is reduced to the freezing point by the **surface** waters being commingled with the warmer waters **beneath** by the intermixture that takes place in the actual flow. Freezing then takes place first below because the water is stiller there, and the pebbles beneath have themselves radiated out their heat until they have fallen below 32° Fahr. The stones thus become covered with ice, and as this ice is of less specific gravity than the surrounding water, it exerts a buoyant effect upon the pebbles, which are thus brought up with it to the surface, as lemon pips are by bubbles of carbonic acid in soda water.

IV. Pack-Ice.—When the surface water of the Arctic and Antarctic Oceans has become frozen, the masses of ice are drifted by the polar currents towards the equator. In thus breaking away from the shore-lines, and proceeding to the south and north, they come into contact with similar masses, and are also jammed together, and thrust over and under each other by projecting headlands, and by sandbanks and shallows. The accumulations thus formed are known to polar voyagers as **pack-ice.**

181. GLACIERS.

SPECIAL INFORMATION FOR THE TEACHER.

I. What a Glacier is.—Glaciers are accumulations of snow in cup- or cauldron-shaped basins, or sloping valleys, on the flanks of mountains above the line of perpetual snow. This snow, being

pressed from behind, is changed into névé, and then into hard blue ice, which melts away at its termination in the valley beneath.

II. Movements.—The causes of the motion are the following:—

(*a*) Pressure, from the accumulated weight of the snow piled up on the flanks.

(*b*) Alternate thawing and freezing, in the day and night, whereby expansion takes place, assisting the downward motion.

(*c*) Tendency to slide down a slope, assisted by the lubricating effect of water flowing beneath. This water has run down from the melted surface and snow on the sides of the valley, during the day time. The weight of the water contained in the glacier mass itself also assists this motion.

The middle moves more rapidly, as in a river. In the upper portion the bottom moves more quickly than the surface; the reverse is the case in the lower portion. In some cases the axis moves twenty times as fast as the margin, so that the glacier becomes wrinkled up from the sides.

III. Glacial Work.—The effects of glaciers are the following:—

(*a*) Ice-Sculpture. Erosion of the flanks of the mountain valleys, and the sides and bottom of the funnel-shaped valleys through which the glaciers pass. These may thus become either wavy, undulating surfaces, smooth as glass, grooved and striated by the rocks, rounded like a whale's back, or scored by gravel and sand borne down by the ice. The latter grind and polish the surface rocks against which the glaciers are borne with persistent pressure through the contracted passages of the mouth of the glacier valley.

These effects are seen in the present glaciers of the Alps, Himalayas, Pyrenees, Iceland, and New Zealand. They are also seen wherever glacial action was one of the factors of disintegration in the past, as on the flanks of Snowdon and on the mountains of Cumberland.

(*b*) Moraines.—Another important effect produced by glaciers is the piling up of moraines, lateral, medial, and terminal. The frost disintegrates large rock-masses on the sloping sides of the valley of the glacier. As these fall on the glacier, they are borne down by it. The glacier itself also scoops out rock-masses from the valley-sides.

(1) When these make a rocky ridge by the side of a glacier they are termed lateral moraines.

(2) When two glacier branches from two adjoining valleys meet in one, uniting the two lateral moraines, we get a **medial moraine.**

(3) The masses left at the termination of the glacier are called **terminal moraines,** and form a natural rock-work, damming up the waters from the melted ice, and often becoming a river source, as is the case with the Rhine and the Rhone.

182. AVALANCHES, GLACIERS, AND ICEBERGS.

INTRODUCTORY SPECIMEN LESSON.

I. Avalanches.—We often see snow falling from the roof of a house during a thaw. The same thing, only on a **larger scale,** takes place on **mountain sides.** The snow while being slowly pressed down the sloping sides sometimes comes to steeper parts, when it suddenly **slides** down into the valleys beneath, just as the partly melted snow fell from the house roof.

II. Glaciers.—(*a*) **What Snow is.** We have seen in previous lessons that each snowflake is made up of little needles, or crystals of ice, mixed with air. A mass of snow is therefore only a mass of ice-crystals with the air between them, and is not so solid as ice.

(*b*) **Application to Formation of Glacier.** A boy in making a snowball is simply squeezing the air out from the snow, and causing the particles of ice to stick closely together. If, therefore, the air in a mass of snow could all be pressed out, the small particles of ice would adhere together and form one mass. This really takes place. The great masses of snow on the mountains are pressed heavily together and the air is forced out, and, as they descend, they gradually change from fields of **snow** to fields, or sheets, of **ice.** The sheets of ice are increased by other masses in descending the mountains, till at last they enter one main valley, and form a "river of ice", to which the term "**glacier**" is given.

(*c*) **Descent of Glaciers.** The glacier gradually descends till it reaches warmer regions, and here, in the day, streams of water are formed which are frozen again at night. At last it reaches some point in the valley beyond which it cannot go, as the warmth melts the ice as fast as it advances; it then forms a **river** which drains the mountain valley of its melted snow.

(*d*) **Action of Glaciers.** As the glacier moves along, it is sometimes rent into very deep and wide openings **(crevasses).** It also grinds against the **sides** of the valley, and breaks off masses of **rock.** In the course of years thousands of tons of rock, stones, and

earth fall upon the glacier. These are carried down the mountains on, and wedged in, the ice, and are deposited in the valley where the glacier melts.

(*e*) **Moraines.** These **moraines**, or accumulations of rock and earth, are found at the **sides**, in the **middle**, and at the **ends** of the glacier.

(1) **Lateral** moraines are accumulations of rocks at the sides.

(2) **Central** moraines are caused by two glaciers meeting; and one side in each case, with their lateral moraines, forming the centre of a new glacier with a combined central moraine.

(3) **Terminal** moraines are rock deposits dropped down where the glacier ends.

III. Icebergs.—The nearer we approach the poles the nearer the sea-level will the glacier descend before melting, till at last we find regions both at the North and the South Poles where glaciers descend to the **sea-level.** Here it is not warm enough to thaw the ice; but masses are broken off by the action of the sea, and these float away as **icebergs.** Icebergs are, therefore parts of glaciers broken off by the sea in colder regions of the world. So large are these glaciers that some of the icebergs are hundreds of feet above the waves, while the part below the surface of the water is many times greater than the part above.

183. NOTES OF LESSONS—EVAPORATION AND CONDENSATION.

Matter.	Method.
I. Evaporation— If we heat some water over a lamp, or on the fire, in a short time *steam* or vapour begins to rise. It is at first "*invisible*"; but as soon as it comes in contact with colder air, it becomes "visible". This vapour is very light,—lighter than *air*,—so it *rises*; and it will continue to do so until it is of the same weight as the air to which it has risen. If we keep the flame, or the fire, under the water long enough, we change *all* the water into vapour or steam. On the *earth* the sun stands for the lamp or fire, and the rivers, seas, lakes, pools, gutters, etc., for the	I. Heat some water in a *flask* over a lamp before the class: note after a time the steam rising. Boil a *kettle*, and notice that close to the spout no vapour appears. (It is invisible.) If the finger be put there it would be scalded. What makes the invisible vapour visible? (Colder air.) Why does vapour rise? (It rises because it is lighter than the air around it; refer to cork, etc., on water.) Will a stone rise? (No.) Why not? (Because it is heavier than the water around it.) Ask what happens when the kettle is left boiling over the fire for too long a time. (It boils dry.) Now apply the lessons of these experiments to the earth. What gives the earth heat? (Sun.)

NOTES OF LESSONS—EVAPORATION AND CONDENSATION—*Continued.*

Matter.	Method.
vessel of water. This water is heated, then turned to vapour, and forms *clouds*. The air takes up the vapour, steam, etc., and holds it as a porous body, a sponge, etc., holds the (*liquid*) water in it. The vapour of water is taken up even in the absence of the sun, by the wind and air, as is seen in wet clothes drying in the shade, etc.	Where is the water? (In the oceans, seas, rivers, etc.) Do we *see* the vapour going up? (No.) When do we see it? (As clouds, mist, fog, etc.) If a piece of ice be left out in the air what at last becomes of it, though it may not melt? (It *dries* up.) If snow be left what becomes of it, without melting? (It also dries up.) What is a better way of expressing this action? (To say the ice and water evaporate.)
II. Condensation— This is just the opposite of Evaporation. We can change the vapour back again into water by cold; that is by abstracting, or taking away the heat. On the *earth* the mountains and cold winds supply the cold, and the vapour passing into cold air is condensed or changed into water again by these. Whatever lowers the temperature brings down some of the vapour into the liquid, or frozen form, if the air be previously full of, or "saturated with", vapour or moisture. Familiar *examples* of *condensation* are seen in the visible *breath*, and the *steam* at the kettle spout, the running down of water on *window* panes, *walls* of rooms, on *glass* of cold water in summer time. This action of condensation is like the squeezing of a sponge filled with water. *Clouds* are the largest instances of condensation in nature.	II. Use a cold slate (dry), and let some vapour from a *kettle* spout settle on this, and note what happens. Or *breathe* on the slate and see the same result. How have the drops of water on the slate been made? (By cold changing or condensing the moisture of the steam of the kettle and of our breath into vapour.) What condenses the moisture in clouds? (Cold air in the upper regions and on mountain sides.) When vapour is condensed, what is formed? (Rain, mist, fog, dew, etc.) Tell class that the word "*saturated*" means full of: and that it is like "satisfied". A child's appetite is satisfied when he is "full", or has had enough of food. Here the air is like the child; and the moisture in it is like the food. The child could take no more than a certain quantity of *food*; and the air can take no more into it than a certain quantity of *moisture*. Ask class for all the familiar instances of *condensation* they can give: and explain the operation in each instance.

184. NOTES OF LESSONS—CLOUDS, RAIN, SNOW, AND HAIL.

Matter.	Method.
I. Introduction— In a previous lesson on *Evaporation* and *Condensation*, we saw that the sun carries up vapour from water, and that mountains condense this.	I. Recapitulate the lesson on *Evaporation* and *Condensation*, so far as to lead up to the phenomena of the causation of clouds, rain, snow, and hail.

NOTES OF LESSONS—CLOUDS, RAIN, SNOW, AND HAIL—*Continued.*

Matter.	Method.
II. Clouds— Clouds are the visible vapour which has risen into the air. They are blown about by *winds*, thus meeting different degrees of cold and warmth. Sometimes they meet with air so very cold that they are condensed or turned into liquid, or *rain*. Sometimes they meet with warmer currents of air, then they *disappear* from sight, the visible changing to the invisible.	II. Take a can of water, heat it, and notice "clouds" of visible vapour rising. How is it that we can see this vapour? (The colder air of the room has condensed it.) Refer to breathing in winter. Let the vapour of breath settle on a cold slate. Show class that the cold slate condenses this vapour from the breath into drops of water.
III. Rain— When condensation happens, the small particles of vapour run together and form "*rain-drops*". *Fogs* are simply clouds low down. The clouds become thicker and denser as the *cold* increases. The particles of moisture come *closer* together, and run into little "*bubbles*", which unite again into *drops* too heavy to hang in the air without support.	III. Apply the preceding phenomena to *clouds* in a cold atmosphere. Tell children they are really in a cloud when in a *fog*. Refer to travellers lost in clouds on mountains. What are rain-drops? (Particles of condensed vapour run together.) Why did the vapour rise? (It was lighter than air.) Why did it run into drops? (The cold condensed it, or made its particles come closer, and unite.)
IV. Hail— Sometimes the rain when falling has to pass through some air cold enough for freezing. When this happens the drops are frozen, and then we call these "*hail*". So that hail is, at least sometimes, rain changed into balls of ice.	IV. Ask children what happens to water when very cold. (It freezes into *ice*.) Apply this to rain-drops becoming frozen. Why does hail fall? (It is heavier than air.) Note that hail damages farmers' crops. Is hail liquid or solid? (Solid.)
V. Snow— When clouds pass into air where it is freezing, their moisture is *frozen*, and becoming heavier than the air, the frozen particles fall in small pieces of irregular shape, called *crystals*. These small pieces of frozen vapour or clouds are called "*snow*". The original water was *colourless*; snow is *white* owing to the air entangled in it.	V. Ask children what would happen if clouds (vapour) were frozen. Is *snow* heavier or lighter than rain or hail? (Lighter than rain and hail.) Will it fall more quickly or more slowly than these? (More slowly.) Drop a feather and a stone, or piece of paper and chalk. Draw a few shapes of snow-flakes on the blackboard.

185. NOTES OF LESSONS—THE SUN.

Matter.	Method.
I. Shape— The sun is seen to be almost a perfect *sphere*, and flattened but very little at the poles. In this respect it is like the moon, and our own globe. All the heavenly bodies are more or less *round*, and all are more or less *flattened at the poles*, or at the ends of the diameters on which they turn round.	I. Show a marble, an orange, and a lemon; and get from the class their differences of shape:— (*a*) *Marble*, round; (*b*) *Orange*, flattened at top and bottom (poles). (*c*) *Lemon*, flattened at middle belt (equator). Compare the sun with the orange, and with the lemon in respect to *shape*.
II. Bulk— (*a*) Though the sun looks to be only about the size of the full moon, and very much smaller than our earth, it is in reality much larger. Its seeming smallness is due to its *distance* from us. (*b*) If a pea stand for or represent the earth in size, one and a quarter million pease all massed together would stand for or represent the sun's size. (*c*) Explain the meaning of *diameter*, and give the sun's diameter in comparison with the earth's: 850,000 miles, or 107 times greater than that of the earth.	II. (*a*) Ask the children to hold up vertically their closed reading-books before their eyes; tell them to note the large surface of a *distant* wall, which the *near* book hides, and explain to them that *apparent* size depends on distance. (*b*) Draw on the blackboard the relative height of a man at a small and at a very large distance from the eye; apply this to the apparent sizes and distances of sun and moon viewed from the earth. (*c*) Give a rough representation of this by *two circles* drawn on the blackboard copied from an astronomical atlas giving the *relative* sizes of the earth and sun.
(*d*) We get an idea of the *distance* of the sun from the earth, when we know that by constantly travelling night and day at sixty miles an hour, it would take us over 170 years to reach the sun. This distance is ninety-two million miles on the *average*, varying according to the earth's position in its orbit, or path taken in its journey round the sun.	(*d*) Draw on the blackboard a representation of the earth in its oval or *elliptical* orbit, and make a *circular* orbit to represent the "*average*" distance of the earth from the sun, which is thus sometimes greater and sometimes less than that marked out by the real path taken by the earth round the sun. Let a boy represent the earth, and travel round another standing for the sun. Mark on the floor the path or *orbit* he takes.
III. Appearance— (*A*) *Our every-day sun* seems to consist of a bright surface of light, called a *light-sphere* (the "*photosphere*"). This consists of metals heated to white heat. When seen through a telescope this surface, instead of being uniformly bright, is found to be covered with *dark patches*, and *bright streaks* of light.	III. (*A*) To explain the word "*photosphere*", refer to the word "*photograph*" (in form akin to *photosphere*) and explain the meaning of the root "*photo*", as light, and *sphere* as ball; so the *photosphere* is the sphere of light ("ball of fire"). Burn a strip of magnesium wire to show that *metals* will give out white *light* and *heat*, and turn to *luminous gas*.

NOTES OF LESSONS—THE SUN—*Continued.*

Matter.	Method.
(1) *Sun-Spots.*—These *dark patches* (*maculae*) in the photosphere, are *cavities* of great size and depth.	(1) Compare these *sun-spots* with the appearance of our earth to one looking at it through a rent in the clouds.
(*a*) *How Formed.*—On the sun there are supposed to be great storms like our *cyclones.* During these storms large quantities of burning gas are forced up in the form of great flames into the sun's atmosphere, like clouds of dust blown up into our own. Here they become cooled, and sink down again to the surface of the sun, and make these cavities.	(*a*) Explain that a *cyclone, typhoon, simoom,* or *hurricane,* is a circular windstorm; and illustrate by an *eddy, water-spout,* or *whirlpool.* Explain to the class that the *moon* has no atmosphere at all; the *earth* has one consisting of air; but that the *sun* has one that is greatly *heated,* and which in consequence is the source of light and heat to us, and to other planets travelling round it.
(*b*) *Difference in these Cavities.*—The difference in the darkness of these cavities is due to their different depths.	(*b*) Illustrate by the increasing darkness seen in looking down wells of a greater and greater depth.
(2) *Bright Streaks of Light.*—These are the *brightest* parts of the sun's surface, and are found near the cavities or sun-spots. They are supposed to be great flames of burning gases forced into the sun's atmosphere (*faculae*).	(2) *Light Streaks.*—These are like "*torches*" flaring up (tell class that this is the real meaning of the word "*faculae*"). Refer again to the blazing up of a burning magnesium wire.
(*B*) *Sun during an Eclipse.*—An *eclipse* of the sun is simply due to the moon passing between our earth and the sun, and so partly covering up the sun from us. When the moon almost *covers* the sun, we see beyond the moon's rim two circles of light. All *opaque* or non-transparent bodies in a light cast a shadow behind them by cutting off the light. The earth and moon, which are opaque, thus carry behind them long shadows trailing through space.	(*B*) Place a lighted candle on the table to represent the *sun,* and let a boy standing for the *earth* describe a path or orbit round this, and another boy representing the *moon* do the same round the "earth". Let the class mark the second boy's (moon's) shadow thrown on the first boy (earth), at certain points ("conjunction"). Refer this to the figures of sun, moon, and earth on a diagram; and draw outlines of ditto on the blackboard, and a drawing of an "annular" eclipse.
(1) *The Colour-Sphere.*—This "chromosphere" consists of immense red and pink flames shooting out from the sun, sometimes 100,000 miles high, which are made of burning hydrogen. Each different substance that will burn has flame of its own *colour*: *magnesium* burns with a white, *hydrogen* with a reddish flame.	(1) Draw a large figure of the sun; continue diameter proportionally, to get the height of 100,000 miles. Light the gas in the school to show that some gases burn with coloured flame; and tell the class that there is *hydrogen* in coal-gas, as there is also in the sun's *colour-sphere.*
(2) *The Sun's Atmosphere* is the second circle of bright silver light	(2) Draw two concentric circles; name the outer one "*atmosphere*", and the

NOTES OF LESSONS—THE SUN—*Continued.*

Matter.	Method.
outside the colour-sphere. It surrounds the sun as the air surrounds the earth.	inner one (closer to it), "*chromosphere*", or colour-sphere.
IV. Heat— This comes from the burning metals and gases forming the bright surface of light, or the light-sphere. (1) *Greater in Summer.*—(*a*) The heat is given off from the sun in all directions in *straight lines.* When we receive these rays vertically, the heat is greater than when we receive them aslant. (*b*) In the earth's motion round the sun, the northern half of the world inclines to the sun in summer, and bends from it in winter. As a result we receive its rays more vertically in summer and more slantingly in winter; and although we are further from the sun in summer, the heat is then greater than when we are nearer to it.	IV. Again burn magnesium wire and hydrogen gas, to show that *metals* and *gases* in burning give out *heat* as well as light. (1) (*a*) Illustrate by a boy's position in *front*, and by the *side* of a fire. In the former case the heat rays from the fire proceed along the most direct course. (*b*) Show a diagram of the *Seasons*, and draw sketch of these on the blackboard, and draw *vertical* and *oblique* rays from the sun to earth. Refer the latter to the former illustration. Explain the words *horizontal*, as applied to the sun's rays at morning and evening; *vertical*, at noon; and *oblique*, between noon and sunset, respectively. The vertical *noontide* rays are the hottest.
V. Light— (1) *Brilliancy.*—The sun's light is much brighter than a lime-light of the same size would be. Yet the lime-light on a mountain in England can be seen on a mountain in Ireland, at a distance of more than 100 miles. (2) *Colour.*—This is white. The white light can be broken up by letting it pass through a prism of glass, and will be found to consist of *seven* colours: violet, indigo, blue, green, yellow, orange, and red, or the colours of the *rainbow*, which really is the white light of the sun split up into seven colours, not by glass, but by rain-drops, acting like glass balls. (3) *Longer in Summer.*—The light of the sun lasts longer in summer, because the part of the earth turned to the sun in summer remains longer in the sun's light than it does in the winter time.	V. (1) Explain that in the lime-light we have hydrogen gas burning (with oxygen), as in coal-gas; but that the dull flame is blown on to a piece of lime, which then "*glows*" white hot, like magnesium wire. (2) Take a prism from a lustre, and hold it up to the sun's light. Let the coloured *spectrum* fall on a sheet of white paper, and get class to name the colours. Draw on the blackboard a figure of the "solar spectrum", and the bands of colour in it in order, putting the names in their proper places. (3) Show on a diagram of the *Seasons* the varying sizes of the arcs of circles at different spots on earth's surface in light and shade, as a measure of the varying lengths of the *days* and *nights* experienced there.

NOTES OF LESSONS—THE SUN—*Continued.*

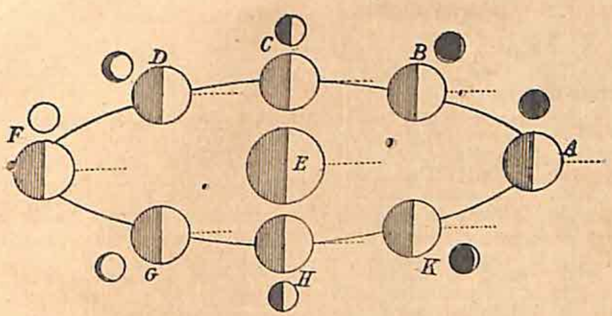
Matter.	Method.
VI. Movements— (*A*) (1) The *apparent* movement is from the east to the west round our earth. This is not *real*; the sun is comparatively fixed, and our earth, moving round on its axis, causes in turn each part of the earth's surface, (*a*) To turn towards the sun. (*b*) To turn away from the sun. (2) *Sun-Rising*, therefore, simply means that our part of the earth's surface where it is early morning is turning or spinning round to the sun. (3) *Sun-Setting* is the reverse, viz., that our part of the earth's surface is spinning round away from the sun at that time.	VI. (*A*) (1) Illustrate this by a diagram on the blackboard, and by a boy turning on his own axis before a lighted candle. Let a button on his clothes represent a man on the earth. Explain the "*apparent*" and "*real*" movements in reverse order, by reference to a really moving, but an apparently still, railway-train; and an apparently moving, but a really still, telegraph pole on the line seen from a moving train. Illustrate by a lighted candle on a table, and a boy travelling round that table to represent the earth moving round the sun.
(*B*) *True Movement of the Sun.*—The sun turns upon its own axis in about twenty-eight of our days. This is *proved* by watching the sun's spots, which are seen to travel across the photosphere from east to west in fourteen days, and then disappear for fourteen days, when they are seen gradually reappearing on the east side of the sun.	(*B*) Illustrate the *true* movement of the sun on its axis by letting a boy standing in the centre of the room represent the sun. Let him slowly rotate, or turn round, on his own axis. Make a mark on him with chalk to represent bright spots (faculae); and as he rotates these will appear and disappear to any one standing outside of the circle on the same side as the sun.

186. NOTES OF LESSONS—THE MOON.

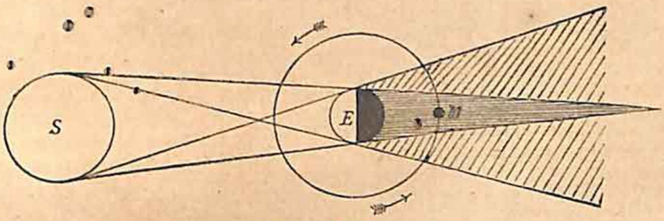
Matter.	Method.
I. Shape— The moon is seen to be an almost perfect sphere, and not so much flattened as our earth is at the poles: that is to say, it is more nearly *round.*	I. Point out that the small comparative difference of the *polar* and *equatorial* diameters of both the earth and the moon is not to be told *at sight.*
II. Size— Though the moon looks about the same size as the sun, she is really very much smaller, and even smaller than our earth. The *apparent* large size is due to her small distance from us compared with that of the sun: about ¼, instead of 92, million miles.	II. Refer back to the illustrations on the sun; and further illustrate by the appearance of a shilling held close in front of the class, and at the opposite end of the room.

NOTES OF LESSONS—THE MOON—*Continued.*

Matter.	Method.
III. Description— (*a*) A bright surface of light, with dark spots upon it. In this respect it is like the sun with its sun-spots, but not from the same cause. Our earth would look to any one in the moon, equally bright, and equally "patchy" in places.	III. (*a*) Get from the class the meaning of the popular phrase of the "man in the moon". Draw on the blackboard a rough representation of the moon's surface, all first filled in with chalk (to represent the *bright* surface); with patches of this rubbed off (to represent the *dark* spots).
(*b*) *Dark and Light.*—The moon has no light of her own, although she looks bright to us. Like our earth she obtains all her light from the sun. So the part of the moon turned towards the sun is light; and the part turned away is dark.	(*b*) Illustrate by an *invisible* mirror in a dark room, turned into a *visible* one by its reflecting a lighted candle, etc., when one is brought into the room. Show a diagram of the moon's "*phases*", and explain them.
(*c*) *Surface and Spots.*—The moon is a planet, somewhat like our earth. The moon has immense mountains higher than those of the earth. Some of these have been volcanoes, and the whole surface seems as if it has been rent by earthquakes. The lower areas are vast plains and beds of dried up seas and oceans.	(*c*) Explain that a "*planet*" is a "*wandering*" body; and why it is so called. (Because it wanders or travels round another and larger heavenly body). Name other solar planets; and show that the moon is a planet to the earth. Give a verbal description of *lunar volcanoes*, etc.
(*d*) *No Atmosphere.*—The moon has no *atmosphere*; and consequently no living *plant* nor *animal*, such, at least, as could exist on our earth.	(*d*) Get from the class what would happen to animal and vegetable life on the earth, if the *atmosphere* became absorbed by the solid crust of the earth.
IV. Movements— The moon has two motions:— (*a*) On its own axis; (*b*) Round the earth.	IV. (*a*) Explain by two boys (standing for the earth and moon) both in motion round a lighted candle (standing for the sun).
(1) *The Moon's Day and Night.*—It takes the moon about twenty-eight of our days to turn once round upon her axis.	(1) Refer back to the astronomical meaning of Day and Night on the earth in Part I.; and apply this knowledge to the moon's day and night.
(2) *Appearances,* or "*Phases*".—The moon also takes twenty-eight days to go round our world. We therefore see different parts of the moon: sometimes more than at others, as *Full* moon, *Half* moon, *Crescent*, and no moon, or *New* moon. This is due to the moon's position with regard to the earth.	(2) Draw a diagram of these *phases*; and name each on the diagram, and point out in what parts of the moon's orbit each is found; and the *cause* of the appearances. Further illustrate by a lighted candle to represent the sun; and a boy standing for the moon. His face is either in darkness (new moon), or light (full moon), or half in darkness and half in light (half moon).
(1) *No Moon,* or New Moon, occurs when the moon is between	Representations of full, half, and crescent moon can be cut out of white paper;



The Phases of the Moon.



A Lunar Eclipse.

NOTES OF LESSONS—THE MOON—*Continued.*

Matter.	Method.
the earth and the sun, and the dark side is turned towards us. (2) *Half Moon* is seen when the moon has travelled a quarter of its way round the earth. (3) *Full Moon* is seen when the earth is between the moon and the sun, and we can see all the lighted surface of the former.	or made by shading with ink portions of the circles thus cut out.
V. Moonlight and Earth-Light— (*a*) The moon has no light of her own, but is only a reflector of the sun's light. (*b*) The earth has no light but that obtained from the sun. Our world, therefore, to any one in the moon, would appear as the moon does to us, only very much larger.	V. Make a mark, to stand for spectator, on a diagram of the moon. Now ask class to fancy themselves the spectator there; get from them what they would then see of the earth. (*First*, a much larger sphere, at night time only. *Secondly*, this would have its phase of "full earth", "half earth", "quarter earth", and "no earth", etc.)

NOTES OF LESSONS—THE MOON—*Continued.*

Matter.	Method.
VI. Eclipse of Moon— The moon travels round the earth. At certain times, therefore, the earth must be between the sun and the moon. The earth, therefore, then prevents the sun's light falling upon the moon, which thus appears a darkened object.	VI. Draw a diagram of the moon in her orbit travelling round the earth. Explain from it the cause of a "*lunar*" *eclipse.* Further illustrate by reference to the explanation of a "solar" eclipse ("The Sun").

PART V.

STANDARDS V., VI., VII.

Government Requirements.—"*Standard V.* (*a*) *Animal or plant life; or*

(*b*) *The principles and processes involved in one of the chief industries of England; or*

(*c*) *The physical and mechanical principles involved in the construction of some common instruments, and of some simple forms of industrial machinery*".

"*Standard VI.* (*a*) *Animal and plant life; or*

(*b*) *The commonest elements and their compounds; or*

(*c*) *The mechanical powers*".

"*Standard VII.* (*a*) *Distribution of plants and animals and of the races of mankind; or*

(*b*) *Properties of common gases; or*

(*c*) *Sound, or light, or heat, or electricity, with applications*".

Revised Code.—Schedule II. *Class Subjects. Art.* 101 (*e*).

The requirements of the Syllabus of "Elementary Science" as a Class Subject are much more intricate, and difficult to provide for in this part of the school curriculum, than in the first four standards.

This is particularly the case in the item (*b*), Standard V., since perhaps no elementary **teacher** in the kingdom is himself sufficiently acquainted with the "**principles and processes employed in one of the chief industries of England**", to be able to give instruction on it for twelve months. Nor would the children, taking the whole of the class, be able to profit by such instruction, even if the teacher could teach the subject. Moreover, the "**chief industries**" vary according to locality, and no provision could be made within the brief compass at our command to help in so wide a matter.

This item is therefore entirely omitted here, as we believe it will be in every non-technical school in the kingdom.

Again, in Standard VI., (*c*), "**The Mechanical Powers**", the subject has been already amply provided for in "Mechanics", and "The Young Mechanic's" Reader, issued by the publishers of this treatise, and this item also is therefore omitted here.

In Standard VII., "Sound, Light, Heat, and Electricity" need to

be taken from special text-books on these subjects, and to be handled after a scientific manner; but schools that are capable of so dealing with them will elect to take them as Specific Subjects, or in connection with the Science and Art Department, rather than as Class Subjects.

The remaining space at our disposal is therefore given to what will be far more generally useful to schools as a whole, viz., (*a*) "**Animal and Plant Life**", in Standards V. and VI., and the allied subjects, "**Distribution of plants and animals, and of the races of mankind**", in Standard VII., thus completing the life series begun in Standard I., and continued throughout; and to (*b*), "**The commonest elements and their compounds**", in Standard VI., and (*b*), "**The properties of common gases**", in Standard VII.

These latter elementary notions of chemical laws and phenomena will be of great use in the fuller understanding of the laws and phenomena of Animal and Plant Life; and, taken in conjunction with all that has preceded, will give as much of the general principles of "Elementary Science" as space here will afford, or the children can learn in taking this subject as a Class Subject only.

THE ANIMAL WORLD.

187. ANIMAL LIFE.

STANDARDS V. (a), VI. (a), and VII. (a).

SPECIAL INFORMATION FOR THE TEACHER.

I. On What it Depends.—The "**life**" of different animals is very various. These differences mainly depend on their **structure**, their **development**, their **habits**, especially as to their **food**, and the means of taking it; on their **abodes**, their **distribution**, and **habitats** on sea, on **land**, in the **air**, or in two, or in all three of these; and on their **relations** to **other animals**, especially in the struggle for food, and thereby for existence itself.

II. Examples.—Each of these items, again, is very varied, and brings with it differences in the **modes of life**; and these, in length of time, also bring about differences of **structure**.

(*a*) Thus, of animals living in **water**, some live in or on **ponds**, some in **pools**, some in **lakes**, some in **rivers**, and some in **shallows**, and some in great **depths** of the ocean.

(*b*) Again, with respect to **food**—the chief cause of the differences

in modes of life, structure, etc.—we have firstly the great division of flesh-eaters, or birds and beasts of prey; and secondly, of vegetable-feeders, as ruminants, etc.

(1) But each of these is again subdivided, thus of flesh-eaters, some feed on insects, some on the flesh of grazing animals, some on fish, some on birds, some on reptiles, and some on each other.

(2) So, likewise, with vegetable-feeders, some feed on grass, some on grain, some on fresh fruits, some on dry fruits only, and some on the juices of flowers.

(*c*) These differences as to the nature of food imply corresponding differences in the modes of securing it, and different organs and structures for these purposes. Thus the carnivorous animals are armed with sharp, strong, and curved beaks and talons, or strong, long pointed canine teeth; whereas the ruminants have hoofs, and incisor and grinding teeth very largely developed.

(*d*) Metamorphosis.—Nor are the modes of life always constant: insects, frogs, etc., undergo changes in these, and have corresponding changes in structure; or they live in stages, or undergo "metamorphosis". There are the life and structure of the grub, of the chrysalis, of the "perfect insect"; the tadpole stage and the frog stage, etc. But each stage is exactly adapted to the requirements of the situation; to the food, and the development, etc., of the time.

(*e*) The colours of different animals also vary, and sometimes in the same animal at different times. And this has in it a purpose; thus the colours of animals, generally speaking, are means of protection, or for the attraction of their fellows. Thus, animals living in the desert are generally of the colour of the desert sands, just as the shrimp is of the sea sand; those in polar regions white, like the snow; and deep-sea animals blue, like the waters seen at great depths. Tigers are striped like the lights and shadows thrown on jungle objects by tall waving grasses; leopards are marked with spots, like those cast by the sun through the leaves of trees. Some animals are coloured like sticks and leaves, so that they are frequently mistaken for these by those that prey on them.

(*f*) Animals differ also as to, (1) Living alone, like the stronger beasts of prey, such as the lion; or, (2) In communities, as bees, ants, etc. In the latter case the work of the colony becomes subdivided, and the structure and habits of the workers accordingly changed to meet this subdivision of labour. Thus, "soldier" ants have immense jaws.

(*g*) Some animals sleep at night, others in the day. This also leads to great differences in the organs of sight, etc., as is seen in comparing the pupils of the eyes of cats and dogs. (*Vide* Part II.)

188. ANIMAL LIFE AND ITS FUNCTIONS.

SPECIAL INFORMATION FOR THE TEACHER.

I. Functions of Animal Life.—A living animal constantly;

(*a*) Exerts mechanical force in muscular movements; and,

(*b*) Gives off heat,

(*c*) Excretes carbonic acid,

(*d*) Gives off water,

(*e*) Undergoes loss of substance in performing the functions referred to in (*a*)-(*d*).

II. Means of Supply.—To enable these functions to be continuously performed two things are required, which may be considered as the raw material for these three functions to work upon:—

(*a*) A supply of oxygen from the air, which necessitates organs of respiration or their equivalents, and of circulation of the blood, thus giving us two great functions of life.

(*b*) Food, solid or liquid, of which flesh-forming foods must be a part, and of which the rest may be fatty, starchy, or saccharine. This implies organs of digestion, and so gives us another of the great functions of life.

III. Waste.—These raw materials, gaseous, liquid, and solid, from the air and from food, after serving their purpose in the animals, are given off in the form of;

(*a*) Nitrogenous excretions, refuse of solid, flesh-forming foods.

(*b*) Water, excretion of liquid food.

(*c*) Carbonic Acid, from oxidation of carbon foods.

(*d*) Saline Compounds, from used-up tissue and food-materials.

Whilst the animal keeps at a constant weight, the sum of the weight of these excretions is the same as the sum of the food and oxygen taken in. If the animal put itself to greater exertion, or do more work, it decreases in weight, or requires more food. If it do less work, or exert itself less, it increases in weight.

The carnivorous animals are the most energetic, and therefore the least fleshy in build; the ruminants are the least active, and the most fleshy.

IV. Organs of Excretion.—In the higher animals these are :—

(*a*) The skin and kidneys, for excreting water principally ;

(*b*) The lungs, for excreting carbonic acid chiefly.

V. Organs of Alimentation.—These are those connected with the digestion of food, or the converting of food into nutriment ; and consist of the mouth, pharynx, gullet, stomach, and intestines.

As animal food is sooner and more easily digested than vegetable food, the flesh-eaters have simpler digestive organs,—seen in their less masticatory teeth, their smaller and simpler stomach, and shorter intestine,—than the vegetable feeders with their grinding teeth, long intestine, and four stomachs especially illustrated in the Ruminants.

VI. Organs of Circulation.—These distribute nutriment, take in oxygen, and take away carbonic acid all over the body of the higher animals. They include in these latter a heart, with connected arteries, capillaries, and veins.

VII. Nervous System.—Governing the three great functions of life just enumerated—Digestion, Respiration, and Circulation—and also regulating the muscular movements of the body and recording the impressions of the senses is the nervous system.

So we may sum up as below :—

LIFE = VITAL FUNCTIONS =
- (1) Circulation and Respiration.
- (2) Alimentation.
- (3) Excretion.
- (4) Nervous Work.

189. CIRCULATION OF THE BLOOD.

SPECIAL INFORMATION FOR THE TEACHER.

I. The Organs supplied with Blood.—Nearly every organ in the higher animals is supplied with blood, since nearly every organ wastes with work, and requires food including oxygen, and means to carry off carbonic acid and other waste matters. The exceptions are the outer skin, nails, claws, hair, teeth, and gristle or cartilage.

II. The Supplying Organs.—These are, (1) The pumping organ of the heart ; and, (2) The blood-vessels. The latter at one part of their course make a mesh or network of fine capillaries with delicate walls of membrane, leaving minute spaces between them

made up of tissues supplied with nourishment from these capillaries.

The larger blood-vessels opening into and out of these capillaries are :—

(1) The **arteries**,
(2) The **veins**, } the muscles in their walls regulated by nerves.

The larger **arteries** have thick stout walls containing a **muscular** coat and highly **elastic, fibrous** substance, to send the blood on to the capillaries. These two coats are not so marked in the veins.

(3) The **heart** has four chambers in Mammals and Birds, three in Reptiles, two in Fishes, one in the lower animals, and is frequently altogether absent in the lowest.

The four chambers are two **auricles** and two **ventricles**.

There is first the contraction of both auricles, then the same in both ventricles, then a pause—this order is repeated so long as life lasts.

The blood is thus pumped from the left side of the heart into the arteries, passes through the capillaries of the body, and thence returns through the veins to the right side of the heart. From this it is passed into the lungs to be purified, returning to the left and again finally to the right side of the heart.

In fishes the blood goes to **gills** instead of to lungs.

190. RESPIRATION.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it is.—This is the **inspiration** and **expiration** of air, (*a*) Among the **vertebrates**—in Mammals, Birds, and Reptiles—to purify the blood by means of **lungs**.

In Fishes the same end is gained through the oxygen held in solution in the **water**, but by means of **gills**.

(*b*) In the **invertebrates** there are either **gills**, or what serve the same purpose in aquatic animals, **air-tubes** in insects, and in the lowest animals no special organs for the purpose of Respiration.

The oxygen of the air taken in at the lungs, gills, etc., is exchanged with the carbonic acid of the blood in the capillaries.

II. The Organs of Respiration.—These in the higher animals consist of the mouth and nostrils, the pharynx, the wind-pipe, the bronchi and bronchial tubes, and the air-cells or air-sacs of the lungs.

The mechanical means employed are :—

(1) The elasticity of the tissues of the lungs.

(2) The muscular movements of the chest-walls and floor.

III. **Results.**—The expired air has been warmed, saturated with moisture, and fouled with carbonic acid and decomposable animal matters in passing through the body. The reverse changes take place in the blood in aeration so far as moisture and waste matters are concerned.

The action and the results of Respiration are modified by cold and by exercise, being heightened by these, as there is more body-heat required in cold weather, and more waste made under exercise.

191. NOTES OF LESSONS—RESPIRATION.

Matter.	Method.
I. Respiration: What it is— This is the function in *mammals*, *birds*, and *reptiles*, by which air is taken into the *lungs*, for the *oxygen* in it to be exchanged with the *carbonic* acid from the blood. It consists of two parts— (1) *Inspiration*, and (2) *Expiration*.	I. Ask children to remember how *quadrupeds* (sheep, etc.), and *birds* (canaries, etc.), pant, or heave the chest up and down in taking in and giving out breath, or in breathing. Frogs also can be seen to *swallow air*. Remind class that "*Inspiration*" means *breathing* in, and "*Expiration*" means *breathing* out.
II. Relation to Circulation— One of the functions of the blood is to carry out waste products to be oxidised at the air-cells of the lungs, to *purify the blood* and to *generate heat*. *Respiration* and *Circulation* are therefore very closely connected; the *aerial* stream brings in the oxygen and carries out the carbonic acid; the *liquid* current takes out the carbonic acid and carries in the oxygen. Again, each circulation is assisted by a *pump-action*, the one of the *lungs*, the other of the *heart*; and both are *involuntary* in their action. (*Vide* Nervous System.)	II. Tell class that in most machines there are several kinds of work going on at the same moment: and if one of these functions be stopped all the machine work will be stopped also. This is still more the case with an animal machine, as that is the most *complicated* of all machines. This is how it is, that it requires one central organ, the *brain* to direct all the body's work, like one commander to the many different regiments in an army. So each of our great *organs* is like a *regiment*, working under the same orders as all others: but doing special tasks. Remind class that our breathing, and the beating of the heart, go on while we are *asleep*.
III. Organs of Respiration— In the lower forms of animal life there is no respiratory *pump*; and in the lowest no respiratory organs at all. Thus in the *salamander*, the	III. Lower down than *Fishes*, there are air-tubes in Insects, and gills in the aquatic Jointed animals; and still lower down no special organs of Respiration at all.

NOTES OF LESSONS—RESPIRATION—*Continued.*

Matter.	Method.
lungs consist merely of two large air-vessels running through the whole length of the body, but not divided up into air-cells, nor provided with tubes. (*Bronchi* and *bronchial tubes.*) As we mount up the scale of animal life, the vessels or lungs become more and *more divided*, so as to give more and more *surface* for the capillaries to spread out upon, and so expose the blood within them more and more to the oxygen in the air-cells for *purification.* The number of divisions in the human lungs is thus enormous.	Make a drawing of an inflated *bladder* in section, and show that if one *partition* be set up in this, it gives an increase of *two* additional surfaces: and so if more and more partitions subdivide it. Show the *capillaries* on the inside of the lower eyelid spread out in the finest mesh-work; and refer to a "*bloodshot*" eye, where the blood-vessels are made visible. Explain that similar blood-vessels line the outsides of the *air-cells* in the lungs, and thus bring the blood in the capillaries near to the air in the cells.
IV. The Lungs— In the highest animals the air passes through the *mouth* to the *windpipe*, and thence into the *lungs* situated in the *chest.* The windpipe branches into two *bronchi*, right and left; these divide and subdivide, and at last end in air-cells connected together by springy elastic tissue. The lungs are therefore a collection of smaller *simple* lungs, like those of the salamander, each air-cell being distinct from every other.	IV. Show the class a boiled *rabbit's lungs*, complete with the windpipe; and a piece of a boiled lung of the *sheep.* Point out on these by dissection the *bronchi* and *bronchial tubes*; and show how *elastic* the tissue is by pressing it like a sponge. Tell the class that many of the organs of the higher animals are found in similar, but *simpler*, forms in animals lower down in the scale of animal life.
V. The Work of Respiration— This is carried on by *reflex nervous* action: that is, one nerve *transmits* to the proper quarters the *impression* of want of pure air; and another *transmits* the *order* to the muscles to work the respiratory pump. This is a subdivision of labour in one and the same department, as distinguished from the same thing in different departments.	V. *Vide* "*Muscle and Nerve*" and "*Nervous Functions*", making a drawing to represent *reflex action*— (*a*) An *ingoing* nerve. (*b*) An *outgoing* nerve. (*c*) A reflex nerve *centre.* Mark (*a*) by an arrow directed *to* the centre, and (*b*) by an arrow directed *from* the centre.
VI. Effects of Respiration— The air coming *out* of the lungs is *different* from that going *into* them in the following items:— (*a*) It has *less oxygen* in it: this having been taken up by the blood in the capillaries in the lungs. (*b*) It has *more carbon* in it, pre-	VI. Remind the class that every function in an animal (or vegetable) body, has a divine *purpose*, or *works towards an effect.* (*a*) Explain that this is the principal reason why *ventilation* is necessary, wherever animals (including man) are assembled. (*b*) Tell class that this excess of *carbon*

NOTES OF LESSONS—RESPIRATION—*Continued.*

Matter.	Method.
sent in *carbonic acid*, this having been given to it from the blood in the capillaries in the tissues.	given off in a man's respiration daily, would be represented by about half a pound of *charcoal*.
(*c*) It has *more water* in it, taken up from the blood and the moist walls of the air passages, pharynx, windpipe, etc.	(*c*) Illustrate by breathing on a cold *slate*; and by reference to the moisture on the windows and walls in a *crowded room*.
(*d*) It has in it *animal effluvia*, or decomposing gaseous animal matter, due to waste of tissue, and the oxidation of this waste.	(*d*) Explain that this is partly the cause of *ill-smelling* (fetid) *breath*; and deduce the consequent necessity of *mouth-cleansing*.
(*e*) It is *warmer*, the heat having been generated in the air-cells, and in the blood, and passing thence to the air exhaled.	(*e*) Remind class that an Eskimo's breath is as warm as a Hindoo's; but the moisture in one freezes as it falls.
VII. Movements of Respiration—The *mechanical* means by which Respiration is carried on in the higher animals are the following:—	VII. Get from class that the whole body like a machine *does work*, and requires *fuel*, and *wears out*; and is made up of *separate parts* (*organs*).
(*a*) The *ribs* are pulled *up* and *down* by muscles, to *enlarge* and *contract* the chest-walls; and thus to allow air to be taken in, and forced out by their pressure on the lungs inside.	(*a*) Ask the class to *feel* the rise and fall of their own ribs in inspiration and expiration, and to *look* at this up and down motion in a child brought in front of the class.
(*b*) This action is assisted by muscles which work from the *shoulder* and *hips*, pulling the ribs up and down for the same purpose.	(*b*) Also ask class to note rise and fall of the *shoulders* in like manner. Explain that they cannot see this movement from the hips (*pelvic* bones), but that it is carried on thence for all that.
(*c*) In *mammals*, there is a *diaphragm*, or partition of muscle and skin, between the chest and the belly. When this is forced up, the lungs are pressed and send out air in *expiration*; when it is pulled down the lungs enlarge in *inspiration*.	(*c*) Explain the position and nature of this by reference to the "*skirt*" of a sheep hung up disembowelled in a butcher's shop; and show a piece of mutton "*skirt*" for class to see its *muscular* and *membranous* structure.

192. ALIMENTATION AND DIGESTION.

INTRODUCTORY SPECIMEN LESSON.

I. What these are.—In animals the nature of the food, and the modes of obtaining it, are the most governing factors of their habits, and even of their structure. This is so because the life of animals depends on a proper supply of **flesh-formers** and **heat-producers**, and the **digestion** of these.

II. Organs of Digestion.—These together make up the great Alimentary Canal, and include :—

(*a*) The **mouth**, with its teeth depending for their shape, number, etc., on the nature of the food.

Among **mammals**, broadly speaking,

(1) The **gnawing** animals have their **incisors** most developed.

(2) The **ruminant** animals have their **grinders** most developed.

(3) The **carnivorous** animals have their **canines** most developed.

Birds have no teeth, they swallow their food whole, and digest it in the gizzard, or in the stomach.

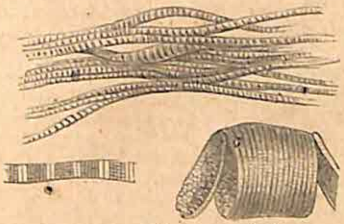
Fishes and **reptiles** mostly use their teeth for seizing and retaining prey, rather than for chewing or masticating their food.

(*b*) The **stomach** is an enlargement of the alimentary canal, and is largest and most complicated in grazing animals (Ruminants), where it is a temporary receptacle for the food, as well as a digestive organ. It is smallest and simplest in the carnivorous animals, as flesh requires less digestion than vegetable matter. In both cases the food is digested by means of **gastric juice**.

(*c*) The **intestines** in vegetable feeders and in flesh-eaters form a long and a short tube respectively, continued from the stomach, and in which the work of the stomach is prolonged, and along which the refuse of food is passed to be finally got rid of.

193. NOTES OF LESSONS—MUSCLE AND NERVE.

Matter.	Method.
I. Introduction— The movements of animals depend on the action, and the *combined* action, of *muscles* and *nerves*. The former are the *obedient servants*; the *latter* the *masters* that give orders. All animals make *some* movements: this motion is to a great extent the mark of animal life. Even the little particles of sponge-flesh, and the other jelly-like animals in fresh and salt water, undergo changes of *shape*, or move some of their *parts*.	I. Show class pictures and diagrams of the human body in the organs :— (1) Of the *muscular* system ; (2) Of the *nervous* system ; and point out how the latter *connect* with the former. Ask class to give, if they can, any animal that does *not* move as a *whole* (in locomotion), or in its *parts*. Refer back to the lesson on the *sponge*, and the method of the *sponge-particles* to bring in currents of water through the pores of the *sponge-skeleton*.
This means, that even the jelly-like flesh has the important power of *shortening* and *lengthening*, or of *contractility*, which is the mark of the perfect muscles of our own limbs.	Bare the upper arm, and by moving the *biceps* show this power of *contractility*, and the *widening* and *lengthening* of the muscles of the arm that take place in its exercise.



Muscular Fibre separated.

NOTES OF LESSONS—MUSCLE AND NERVE—*Continued.*

Matter.	Method.
In the *higher* animals these motions are controlled by a *nervous system*: and in the highest of all (Mammals, Birds, Reptiles, and Fishes), by a *brain* and *spinal cord.*	Show a diagram of the *brain* and *spinal cord* in one of the *Vertebrates*; and of the *ganglia* of an *Insect*: and point out the nerves in each case going into, and out of, these.
II. Voluntary Movements— Animals have *two* different sets of *muscles*, for doing *two* different kinds of muscular *work*. One of these sets are the *voluntary muscles*, and the work these perform is *voluntary* work; or work performed in obedience to the *will* of the owners, and which can only be done when they are awake. (*a*) *Voluntary muscle* is generally *red* in colour, because of its being furnished with a good *blood-supply*. This is the ordinary "*flesh*" of "*meat*", of a leg of mutton, shin of beef, etc. (*b*) It is generally attached to *bones*, either *directly*, or by means of *tendons*, as in the muscle of our own upper arm connected by tendons with the shoulder blade; and by another with the fore-arm. (*c*) The muscle is *wrapped up in a sheath*, binding it all together into one bundle. (*d*) Each muscle breaks up into smaller and smaller *fibres*, as a rope does into strands. (*e*) These fibres are *striped*, or crossed transversely by *stripes*.	II. Ask class to try to stop their *breathing*, or the *beating* of their hearts. Put class through some drill *extension* motions and bring them suddenly to the "halt", and show them that they have power of control over their *voluntary muscles*, and that the work they perform with these is thus *voluntary* work. (*a*) Ask what is the colour of the flesh or meat bought in a *butcher's shop*; and what makes it of this colour: and contrast beef with the paler colour of veal, which has had part of the blood drained out of it. (*b*) Ask class what the butchers sell *with the meat* on every joint (*bone*); and why a mass of meat is called "*a joint*" at all; and why a piece of liver, heart, or lights, could not be called a "joint" of meat. (*c*) Make a drawing of this on the blackboard from a diagram. (*d*) Do the same with this item, and compare the muscle with a *rope* made of separate *strands*. (*e*) Draw on the blackboard the *stripes* on a single fibre of voluntary muscle.
III. Involuntary Movements— The other set of muscles which animals have are the *involuntary*	III. Refer to all actions that take place in the body during *sleep*, when our

NOTES OF LESSONS—MUSCLE AND NERVE—*Continued.*

Matter.	Method.
muscles. The work they perform is *involuntary* work, or work done without orders from the will, and generally without the *knowledge* of the owner, as in the beating of the heart and the movements of respiration. Involuntary motions do not *fatigue* us as voluntary movements do.	will, as well as our body generally, is inactive. These will include *circulation*, *digestion*, and *respiration*, as the three great functions carried on by *involuntary muscles.* Point out how *necessary* to life it is that these should be so carried on *without our will.*
(*a*) *Involuntary muscles* are generally *pale* in colour, *not* red as in the preceding.	(*a*) Draw a diagram of these on the blackboard from Murche's text book of Physiology.
(*b*) They do *not* connect *bones* together; but make thin *flat layers*, arranged round *hollow organs*, such as blood-vessels; or they make *thin sheets*, as in the walls of the stomach.	(*b*) Refer to the *heart* as the organ of *circulation*; to the *stomach* and *intestines* as those of *digestion*; and to the *lungs* as that of *respiration*; all without bones (except a small one in the heart).
(*c*) Generally speaking, they are *not wrapped in a sheath.*	(*c*) Show this in a drawing, and compare this with drawing in II. (*c*).
(*d*) They break up into bundles of *spindle-shaped cells* placed side by side.	(*d*) Draw these *spindle-shaped* involuntary fibres on the blackboard.
(*e*) They are *not striped*, except in the heart, where they are also *red*, but *not sheathed.* They do not undergo the same strain from hard muscular work as the voluntary muscles do.	(*e*) Explain that the heart does more regular and continuous *muscular work* than any other organ in the whole body; and therefore its involuntary muscles are of a very high order.
IV. Voluntary Muscles at Work— Each muscle can exist (1) In a state of *work*; and (2) In *rest.* It is provoked out of the latter to the former state by some spur, or *stimulus*, generally acting on it through a *nerve.* This makes the muscle fibres contract, or shorten, and at the same time to widen or increase in thickness. Electricity, a blow, a strong chemical substance, etc., may be the stimulus: or it may be an order from the will through the brain.	IV. Illustrate this by the *biceps* in *rest* and in *action.* Set this into action by a smart *blow* on it, or by a slight *prick* of a pin. Explain this item by reference to the use of the *spur* or *whip* to a horse. Explain that as the muscle does not take up any *less room* in action than in rest, if it shorten it must become thicker or wider, and reversely.
This work will go on only so long as the muscles are supplied with pure blood to feed it, and to carry off the waste in it made by work.	Tell the class that the *wages* the muscles get for *work* are *board-wages*, or *food* brought in by the *blood.*
Whilst working, the muscles give off *heat.*	Illustrate by our getting hot partially from violent muscular exercise.

194. ANIMAL MOTION AND LOCOMOTION.

SPECIAL INFORMATION FOR THE TEACHER.

I. **What these are.**—By motion the movements of parts of the body only is meant; by locomotion the movement of the body as a whole. The latter is mostly dependant on the former; the latter also depends, in different animals, largely on their food and habitats.

A. Vertebrates. (*a*) Thus in mammals, we have generally four well-developed limbs, two fore-legs or arms, and two hind-legs.

(*b*) In birds, the fore-legs or arms are replaced by wings.

(*c*) In reptiles, there may be two or four legs.

(*d*) In fishes, there are no legs, but fins, which take their place, and a tail.

B. Among the Invertebrates, the limbs in one group, Jointed Animals (Articulata), consist of six, eight, or ten legs (*vide* Part IV.). Lower down in the scale of animal life, there are very various organs of locomotion, and still lower, none at all.

II. **Muscles.**—In these we have the chief instruments of motion and locomotion in animals. They consist of bundles of fibres, which have the power of shortening and widening, and in the doing so of moving the parts, especially the bones and joints, to which they are attached.

Muscles are of two kinds:—

(1) Muscles attached to solid levers, as those moving our limbs; and,

(2) Those not so attached, or hollow muscles, as those of the heart, blood-vessels, alimentary canal, etc.

III. **Joints.**—These are of two kinds:—

(1) Imperfect joints, and,

(2) Perfect joints.

(1) The former are connected together by gristle, or ligaments, with only a slight motion on each other, as in the joints of the backbones of all the vertebrates. In the mammals and birds these are connected together by the slightly convex faces of the joints being filled with cartilage between them; in the reptiles by convex and concave surfaces; in the fishes by concave surfaces filled with cartilage.

(2) In the perfect joints the opposed surfaces are also protected by cartilage, but there is freer motion on each other, as in the

ball and socket joints of the shoulder and hip, the hinge joint of the elbow, and the pivot joints of the head.

IV. The Ligaments are strong and fibrous, and surround the joints on all sides, as in the knee; or on two sides, as in the elbow; or they are inside the joints, as in the hip.

V. Motions.—The movements of which the joints of animals are capable are:—Bending, extending, and withdrawing the limb, and rotating it; in walking, running, leaping, bounding, galloping, flying, swimming, etc.

195. NERVOUS FUNCTIONS.

SPECIAL INFORMATION FOR THE TEACHER.

I. What they are.—Most of the animal movements are due to a stimulus applied to the outer extremities of a nervous system, and transmitted thence to the central organ,—or the brain in the Vertebrates, and to masses or swellings of nervous matter taking the place of this in the Invertebrates,—from which outgoing orders are sent to the muscular apparatus. (For illustration see page 193, Position of Brain and Spinal Cord.)

II. Sensations.—These are general and special.

Among the former are the sensations of fatigue, faintness, restlessness, and other organic sensations of a diffusive, vague kind.

The latter are those of Touch, Taste, Smell, Hearing, and Sight, all of which are present in the Vertebrates, and some very highly developed in the Invertebrates. These require special organs, as the skin, tongue, nose, ears, and eyes. It is these special sensations, together with hunger and thirst (organic), that mostly govern the actions of animals; whilst man is also moved by Will and Reason.

III. The Central Organ.—This is the brain, with its continuation the spinal cord. Most of the actions of animals are instances of reflex action, in which the spinal cord is greatly concerned. Something excites the outer extremity of a nerve going into the cord; this excitement is converted into an order sent along a nerve going out from the cord to the muscles. The muscles thus receive an order to put themselves into motion, as in a horse treading with pain on a sharp stone, and in consequence sharply withdrawing the foot from it.

The cord also acts as a receiver of nervous messages, or a channel of communications, sent up and down to and from the brain.

196. NOTES OF LESSONS—THE COVERINGS OF ANIMALS.

Matter.	Method.
A. Vertebrates. I. Hair— This is the general covering of the *mammals*. It differs in *thickness*, *length*, and *colour*, according to the *season*, the *climate*, and the *habitat* of the animal, sometimes varying in the same animal with changes of seasons. It is generally coloured so like the owner's natural surroundings that it can escape its own *enemies* and approach its *prey* unobserved. In the *thick-skinned* mammals hair is little needed, and so little developed. In a whale it is not at all needed, so is not found in the full-grown animal. In cold climates it changes into, or is replaced by, *wool*; and in still colder by *fur*. The *fur-bearing* animals are thus limited to Arctic regions. The wool of the sheep changes according to *breed*; and becomes finer or more like hair according to *migration*; compare *alpaca*, *merino*, and other wools. Wool can be cut off by man, but fur has to be removed with the skin. Of the three, fur is the worst conductor of heat, then wool, then hair; and this is therefore the order of their warmth to the *owner*, and of their similar use to *man* for clothing. In addition, there are for the latter varying degrees of *length*, *lustre*, and *fineness* modifying the commercial value. A few of our domestic animals have fur, as the cat and tame rabbits.	I. Show class specimens of hair, wool, and fur. Ask the children to give the names of the two great *divisions* of animals, the *Backboned* or *Vertebrates*; and those without backbones, or the *Invertebrates*. Next ask for the great *Classes* of the Vertebrates, and the order of their development beginning with the highest, *Mammals*, *Birds*, *Reptiles* and *Fishes*. Call attention to the different *habitats* of these, some on the *ground*, some in the *air*, others in the *water*; and the need on this account for different *clothing* or natural coverings. Do the same with their different *habits*, *localities*, etc. Ask for instances of the *thick-skinned* mammals (elephant, rhinoceros, hippopotamus, etc.), and call attention to the few hairs seen on an elephant in a menagerie. Show class specimens of different *wools*, and compare and contrast them. Do the same with *hair*, *wool*, and *fur* compared together; and draw diagrams on the blackboard of the individual fibres of hair and wool to show their differences of structure. Show class a specimen of a woven fabric in alpaca, merino, and ordinary flannel. Explain the meaning of "*conduction of heat*", and upon what it depends; and illustrate our use of this knowledge in our selecting different clothing materials for different purposes.
II. Feather— This is the special covering of *birds*, and is not found on any other Class. It is never *absent* from this Class, though it is *modified* in the penguin, and some other aquatic birds taking on the habits of fishes.	II. Show class a *feather*, and point out its *parts* and what constitutes its *lightness*. Illustrate the "*warmth*" of feathers by referring to feather boas worn round the neck for this reason, and because of their beauty and lightness.

NOTES OF LESSONS—THE COVERINGS OF ANIMALS—*Continued.*

Matter.	Method.
Feathers are *worse conductors* of heat than even fur, and so "*warmer*"; and therefore *better suited* to keep up the higher temperature of the blood necessary to Birds. It is also *lighter* than fur, wool, or hair, and so better adapted for creatures of *flight*. Feathers would not be suited to the Class above (Mammals), as they would not resist the damp in lying on wet ground: nor to the Classes below (Reptiles and Fishes), as they would not stand wear and tear of *creeping* on the ground in the one case, and would impede motion through *water* in the other.	Remind class that Birds are to be found in the *coldest* regions quite close to the North and South Poles; and in the *air*, out of *shelter* of caves and forests, and that even their *nests* are not built for their own shelter and warmth, but only for the purposes of laying their eggs, and hatching and rearing their young. Many also swim in Arctic *seas* of icy coldness. Call attention in these cases to the extra warmth secured by the *down* at the base of the other feathers, and how warm this is, as illustrated by its use for beds, quilts, etc.
III. Horny Scales— These make the covering of the larger *reptiles*, such as the alligator, crocodile, tortoise, turtle, etc. These plates are *stronger* than any other covering of animals to resist mechanical wear and tear in crawling or walking with a *dragging* motion over rough surfaces of the ground and the bottoms of lakes and rivers. This covering would not be suited for the Class above, nor for that below, because of its *weight*.	III. Ask the class why *feathers* would not be suited to the habits and habitats of the *Reptiles*. Show class pictures of the crocodile, alligator, and tortoise, and if possible a living specimen of the latter; and also a piece of tortoise-shell in the form of a comb, book-cover, etc. Compare this covering with the *plate armour* of a knight in olden times, and note the awkward ungainly gait given to the wearer in both cases.
IV. Scales— *A. Vertebrates*—These admirably suit the Class of *fishes* in giving protection against mechanical resistance, and in being yet *light*, occupying very little *space*, offering no resistance to motion in *water*, and keeping out the wet. *B. Invertebrates.*—These scales also are seen on the wings of butterflies (Insects).	IV. *A.* Show the class a *fish* (herring), and scrape off the scales of this with a knife from the tail to the head to show the class how they *imbricate*, or overlap each other, at one end, and are *free* at the other or opposite extremity. *B.* Refer to the lessons on Insects in Part IV.
V. Hard Skin— This is the protective covering of insects and spiders, and is suited to their habits and habitats.	V. Refer to the horny wing-cases of *beetles*, and to the tough leathery skin of *spiders*.

NOTES OF LESSONS—THE COVERINGS OF ANIMALS—*Continued.*

Matter.	Method.
VI. Scaly Plates— These are the covering of most of the *Crustacea.*	VI. Show class a *crab, lobster, shrimp,* or *prawn* to illustrate these.
VII. Shell— This is the protection for most of the *Mollusca,* and can sometimes be detached from the wearers.	VII. Show children a *periwinkle, whelk, snail,* and *cockle,* to illustrate the coverings of the mollusks, or soft-bodied animals.

197. DISTRIBUTION OF ANIMAL LIFE.

SPECIAL INFORMATION FOR THE TEACHER.

I. What it means.—Animals, like plants, are of various sorts and kinds, and are found all over the surface of the earth from the equator to the poles, and from the lowest valleys to the tops of the highest mountains, and on land and water, in seas, lakes, and rivers.

In opposite parts of the earth's surface we generally have totally different kinds of animals, though the climates of the two countries may be nearly or quite alike; so the distribution does not depend merely on climate.

Thus the animal life in England may be compared with that in Australia, as in the following table:—

England.	*Australia.*
Hare.	Kangaroo.
Squirrel.	Duck-mole.
Sparrow.	Parrot.

But half-way between these extremes, as in India, the differences of the animal life are less; still nearer to England, as in Egypt, the animal life is still more like that in England, but less like that in Australia; and in France it is almost identical with that in this country.

Again, there are like, or nearly similar, climates in the same latitudes in America, Asia, and Africa; but the animal life is very different; so there must be something else besides climate to give rise to these differences.

II. Laws of Distribution.—(1) The greater the distances asunder, the greater the differences of animal life; and, con-

versely, the nearer two countries are together, the more nearly alike is their fauna, or animal life.

(2) Every group of the same kind of animals occupies a definite area on the world's surface, as of the lion in Africa and South-Western Asia including India, and the tiger in Southern Asia and Australasia.

But bats are found in every part of the world except the polar regions; carnivorous animals everywhere except in Australia; but pouched animals, like the kangaroo, in Australia, and the opossum in the New World.

III. Mammals.—These live either on land or sea. In the one case, the land is the means of their distribution; in the other, the land is a barrier to distribution.

Land Mammals are found everywhere on the continents except at the tops of the highest mountains; but the remote oceanic islands are mostly without them.

The principal facts of their distribution are the following:—

(1) There are no insect-eaters in South America; but many toothless animals there, as the sloth, ant-eaters, etc.

(2) Pouched animals prevail in Australia, and are found also in America.

(3) There are no mammals at all except bats in the remote Pacific Islands.

(4) There are no pouched animals, but all the higher mammals, in Europe, Asia, Africa, and North America.

IV. Birds.—As these are provided with powerful means of progression, we find them much more widely distributed than Mammals or Reptiles, and also more accustomed to migrating to long distances, chiefly on account of food and the varying difficulty of obtaining it at different seasons.

V. Fishes.—The same remark applies in a less degree to fishes, and for the same reason, so far as wide distribution is concerned. Their migrations are not so general nor so extensive, and frequently depend on spawning, or depositing the roe of the female, on shallow sea-shores.

198. NOTES OF LESSONS—DISTRIBUTION OF ANIMALS.

Matter.	Method.
I. Introduction— *Causes of Distribution.*—(*a*) The principal cause of animals being distributed into "*zoological re-*	I. (*a*) Explain terms "*Fauna*" and "*Flora*" as the sum total of animal and vegetable life, the one belonging to the

NOTES OF LESSONS—DISTRIBUTION OF ANIMALS—*Continued.*

Matter.	Method.
gions", each marked with its own characteristic *fauna*, or total assemblage of animal life, is *geographical*. This is explained by supposing that animals have wandered from *starting* points, or *cradles* of their birth and rearing; and that the farther they have wandered the more *different* they have become from their parent stock.	science of *Zoology*, the other to that of *Botany*; and both to *Natural History* in its widest sense. Tell class that no two children in the same family are so exactly alike that their parents mistake one for the other. There are thus "*family likenesses*" and *individual differences*. So it is with *Plants* and *Animals* generally.
(*b*) But this has a *difficulty* in it, since areas widely apart in *distance* and separated by *impassable* oceans, as South America and Australia, have *similar* forms of animal life, or "*representative species*", in the opossum and kangaroo, both belonging to the "pouched animals". But the difficulty *disappears* when we remember that the *present* land and water areas were not those of the distant *past*, and that lands which are now separated were once contiguous.	(*b*) Remind class that *England* was once joined to the *Continent*, and the Isle of Wight to Hampshire; and that the sea has since separated what was once united. We therefore have the same kinds of animals on the mainland as in the Isle of Wight and in Europe. Tell class of these shore-lines in England now being *washed away*, as the chalk cliffs of Kent and Sussex; and of others *rising*, as the Maplin Sands in Essex; the sea and land interchanging.
(*c*) But along with *distance* from the central starting point, and in consequence of it, are many *smaller causes* of difference in the nature of the animal life thus travelling on in waves, and becoming more and more changed, and therefore less and less fitted for their old surroundings, and more and more suited to new. Among the chief of these were and are the following:—	(*c*) Explain to class that just as a boy is often less like his *grandfather* than his *father*, *time* giving greater opportunities of change of family likeness, so *space* or distance, and new countries, alter the animal life as it passes through from the cradle of the race; and that this change in *home* with animals is accompanied by changes due to *time*.
(*a*) *Differences in climate* in— (1) *Temperature.* (2) *Moisture.* (3) *Duration of sunlight.*	(*a*) *Vide* "*Distribution of Plants*" *infra*: and run these two items, viz., fauna and flora, together. Give instances of animals that perish in (1) a *cold*, (2) a *dry*, or (3) a *gloomy* climate respectively.
(*b*) *Situation and Elevation*, as modifying climate.	(*b*) Draw a diagram of a mountain with *zones* of *animal* life on it, (*vide* "Plants", *infra*).
(*c*) *Character of Soil*, as determining character of food, especially in the case of the grazing animals, or Ruminants.	(*c*) Remind class that there are three "*kingdoms*" in nature; but that in the end the *Animal* and *Vegetable* Kingdoms subsist on the *Mineral*.
(*d*) *Relation to other Animals*, as a question of *food*:—(1) Of *animal* food, as between the *flesh-eaters* and their prey, and among each other:	(*d*) Explain that if any *single* species of animal (or plant) had the world left to itself it would fill it with its offspring. It would only be a question of *time*. So

NOTES OF LESSONS—*DISTRIBUTION OF ANIMALS—Continued.*

Matter.	Method.
and (2) Of *vegetable* food, as between the *Ruminants* in the struggle for existence. Thus lions are few in any district, and absent where there are no animals to feed on.	there is a constant *struggle* going on between animal and animal (and plant and plant), and the *strongest win* and retain their foot-hold.
(*e*) *Depth of Water* in the case of marine animal life, the fauna of *shallow* waters being very different from that at great oceanic *depths*.	(*e*) Show class the two different kinds of crabs (dog-crabs and edible crabs), found in *shallow* and in *deeper* waters of our own shores (*vide* Part IV.)
II. Barriers— *Barriers* to *migration*, *dispersion*, and consequent *distribution* of animal life, are met with on the earth, as in the case of the flora: and they are usually the same, but act to a less extent, as animals have power of *locomotion*, especially in *Birds*. These are:—	II. Point out to class that animals cannot go *wherever* they *like*, though they can go *farther* and *faster* than *plants* which have to wait until animals, winds, etc., carry their seeds for them into new regions. Refer to lesson on "Dispersion of Seeds", *infra*.
(1) *High Mountain Ranges* shutting off Zoological as well as Botanical Regions, as in the Himalayas, between the animal life of India and that of Tibet.	(1) Remind children of the preservation of tribal manners, language, religion, etc., in valleys separated by high mountains.
(2) *Rainless Deserts*, as in the Sahara, separating the abundant life of central and southern Africa from that of the Mediterranean shores.	(2) Remind children of *armies* and *caravans* that have been *swallowed up* in deserts, and of the scanty animal life (and vegetation) found in these.
(3) *Climate* as determined by latitude. But here the change being less abrupt, animal life becomes *gradually* modified by the intervening climates, so as to be only greatly different at the *extreme ends* of the "Zoological Provinces", especially from north to south.	(3) Name the chief factors of climate (*temperature and moisture*), and explain how these roughly depend on *latitude*. Point out how *gradual* these differences appear if we travel from the equator to the poles, and if we do so only slowly, as the animals would do in search of fresh pasture or prey.
(4) *Oceans* in the case of *land* mammals and reptiles, and to a less extent in *birds*: but with only the barriers of temperature and depth in the case of *fishes*.	(4) Remind the class how long the *New World* remained unvisited by men from Europe, though these had used ships for thousands of years, a wide extent of ocean being thus a barrier to man at one time.
(5) *Rivers.*—*Swift*, *wide*, and *deep* rivers also check the passage of the higher groups of animal life from one district to another, except in the case of those that can *swim*.	(5) Point out how frequently rivers are the *boundaries* of countries, because they keep even *men* asunder, until bridges and boats are built for their crossing.
III. Representative Forms— As there are *two* great land masses, the *Old* and the *New*	III. Point out these hemispheres on the map of the world, and the points at which

NOTES OF LESSONS—DISTRIBUTION OF ANIMALS—*Continued.*

Matter.	Method.
World, we should suppose that this division would give us great corresponding differences in their *faunas*; and this is so. But as these divisions have not *always* existed as at present, we should suppose that there would remain in each some forms that, notwithstanding alterations due to changed surroundings, would remind us of a *common parent stock*. This is also the case. Among the most striking examples of these Representative Forms are the following:—	they nearly *touch* at present: and the great sheets of water between them now in the southern hemisphere between South America and Africa. Remind class that as *England* is slowly and bit by bit thus becoming sea at one point of the shore, and land where it is now shallow sea, so it is with the *continents*. Only it takes longer for them to be all changed than with a *small country*, as there is more to alter, or more work to be done by the forces of nature. Remind class that the *puma* is frequently called the "*American lion*".
Old World. — New World. *Carnivorous.* Lion. — Puma. Tiger. — Jaguar. *Ruminants.* Camel. — Llama. Buffalo. — Bison. *Thick-skinned.* Elephant. — Tapir. *Pouched.* Kangaroo. — Opossum. *Birds.* Ostrich. — Rhea and Emu. *Reptiles.* Crocodile. — Alligator.	In both the *jaguar* and succeeding instances the New World representatives are the *weaker* of the two. Tell class that the *llama* resembles the camel in its peculiar *stomach* with its *water-cells*. Tell the class that the *bison* has now nearly *perished*. Show a picture of the *tapir* with its *thick skin* and "attempt at a *trunk*". Explain why the *kangaroo* and *opossum* are called "*Pouched Animals*". Remind class that *ostriches* and *emus* are "*Runners*". Both *crocodiles* and *alligators* are found in rivers.

199. NOTES OF LESSONS—RACES OF MANKIND.

Matter.	Method.
I. Caucasian— (*a*) *Habitat.*—This is also called the *white* race from its general colour. But this varies from the fair complexion of the Anglo-Saxon, to the dark, swarthy Italian, and the olive complexion, approaching to black, of the Hindoo. It is also called the *Indo-European*, because it is found from India to West Europe; though it has also migrated thence to North and South America, the shorelines of Africa, and to New Zealand and Australia, and to almost every other part of the world.	I. (*a*) Point out on the map of the world the wide range of this race in both the Old and the New World. Refer to the *exceptions* in Europe (*Vide* "Mongolian" *infra*), as the Lapps, Finns, and Magyars. Point out that Europe has been successively invaded from the east by waves of people coming, (*a*) From the south-east, and (*b*) From Siberia, and that in the former case we get the Indo-European element of admixture, and in the latter the Mongolian.

NOTES OF LESSONS—RACES OF MANKIND—*Continued.*

Matter.	Method.
(*b*) *Description.*—Generally fair skin, long silky hair, especially in the women, straight or arched eyebrows, eyes set level, well-proportioned face and body. Highly developed intellectually, and hence the most enterprising of all races.	(*b*) Refer for the indications described to the children in the class as concrete illustrations, and show pictures of people from other countries of Europe, to mark how they generally agree in the points mentioned.
II. Mongolian— (*a*) *Habitat.*—This is also known as the *yellow* race, from the colour of the skin and of the "whites" of the eyes. It is found chiefly in China and the east and north of Asia, and derives its name from Mongolia, the probable cradle of the race. There are also remnants of the race descended from original Mongolian invaders of Europe from the east, in the Lapps and Finns of the north of Europe, and the Magyars of Hungary; and also in the Russians, especially in those living to the east of the River Volga. The Red Indians are also very like the Mongolians in high cheek-bones, eyes set obliquely, etc. (*Vide infra.*)	II. (*a*) Ask what children have seen a Chinese, and get from them what they noticed about this person. Point out on the map where *China* and *Mongolia* are, and tell the class that the Chinese have existed as an agricultural people, little mixed with "foreigners" or "barbarians", as they call such, for thousands of years in the basins of their two great rivers. Show where the Finns, Lapps, and Magyars are now found. Explain what will be the future in the United States of North America, where probably only a few Red Indian descendants will finally hold their ground against the white man.
(*b*) *Description.*—The skin is yellow, the eyes are set obliquely, the hair is lank and does not cling and fit to the shape of the head as in the Caucasians. The cheek-bones are prominent. The race is of inferior civilization to the Caucasians, but much more ancient. It is patient and persevering, yet not rapidly progressive; but still capable of carrying on commerce and industry, both at home and abroad.	(*b*) Show a picture of a Mongol or Tartar, or, in the absence of this, of a Chinese. Get from it the various characteristic features mentioned in the "Matter" column. Refer to the ingenuity and inventiveness of the Chinese, and their invention of block-printing, gunpowder, and river locks; and to their stationary civilization, and hatred of the "western barbarian", and to the wars this has led to.
III. Negro— (*a*) *Habitat.*—This also known as the *black* race. It is generally darker than the others, but there is much difference of degree in this, and the type is not so fixed as in the others, shading off very much in its native home in Africa. It is also met with in the Southern	III. (*a*) Tell the class that the word "*negro*", or its commoner and baser form "*nigger*", means *black*; and why the race is so called. Show the habitat on the map of Africa; and, in the New World, their place of transportation and settlement in the Southern States of North America.

NOTES OF LESSONS—RACES OF MANKIND—*Continued.*

Matter.	Method.
United States, carried thither in old slave-running times, and now numbering many millions, and increasing at a greater rate than the white man there (except as added to by immigration). (*b*) *Description.*—The *colour* is black, the *hair* crisp, short and woolly; the cranium bones thick and capable of resisting great solar heat, making the race with its fine muscular development the only one fit for hard labour in tropical climates. The heels project behind, and the feet are flat. The *lips* are very thick, and the *nose* is compressed and broadened at the base.	Tell the class that the negro must have existed many thousands of years in Africa, for he is plainly figured just as he is now in the sacred picture-writing of the ancient Egyptians. (*b*) Ask what children have seen a negro; and get from them, or from a picture of the negro race in the "*Races of Mankind*", or from a picture in a reading-book, the points mentioned as to *colour*, *hair*, *lips*, and *nose*. Explain why the thick skull and muscular development of the negro have led to his capture and deportation into slavery in the sugar and cotton plantations of the West Indies and United States.
IV. Malay— *Habitat and Description.*—This race is smaller and less distributed than any of the preceding. It is found chiefly on the Malay peninsula, which may be regarded as the cradle of the race, and in the adjoining islands of the more distant Madagascar. The Malay has the skull of the Caucasian, the hair of the Mongolian, and the flat feet of the Negro, with modifications of a minor degree in all these. In civilization the race is generally of a low type, being usually semi-barbarous, and liable to sudden murderous impulses.	IV. Point out on the map of Asia the peninsula of Malaya; and show pictures of Malays, in reading-books, or in Johnstone's "*Races of Mankind*"; and ask what child has seen a Lascar sailor (in London). Show Madagascar on the map; and point out to the children what a great distance Madagascar is from Malaya, which we must regard as the probable cradle of the race. Explain that savages in their war-canoes have been sometimes found twelve hundred miles from the nearest land, having been carried thither out of their course by adverse winds. Remind class of sudden mutiny and murder sometimes committed by Lascar crews.
V. Red Indian— *Habitat and Description.*—This race is still less numerous than the preceding, amounting only to about half the calculated number of the Malays. It is also fast dying out before the encroachment, the adopted vices, the diseases, and the higher civilization, of the white man in North and South America. The race is strictly confined to the New World. The skin is red or copper-	V. Explain to the children, that when the white man first set foot in the present United States, the red man was already in possession of all the land. Explain that new races are very apt to take the diseases of new comers, and to have them in a more violent form; and that the *small-pox* has destroyed many Red Indians. Also show that barbarous tribes have not the religious influences which civilized races enjoy to help them to struggle against the vices of the civilized; and that

NOTES OF LESSONS—RACES OF MANKIND—*Continued.*

Matter.	Method.
coloured, and gives the name to the race. The hair is lank as in the Mongols, of whom the Red Indians appear to be a variety, probably introduced by migration across Behring Strait from eastern Asia. They have also the same prominent cheek-bones as the Mongols. They are not very capable of higher forms of civilization, though there is some progress in this matter to be seen in the locations allotted to them by the United States Government, and in the Dominion of Canada. They are found in both North and South America, and are very mixed in the latter case with other races. There would be no impassable barriers between North and South America to isolate them, as the mountain axis of the New World runs north and south.	drunkenness and "fire-water" slew more than small-pox. Show on the map how easy it would be for Mongols from eastern Asia to cross over to western America; and how like the Eskimos and Red Indians are to the tribes of north-east Asia and Siberia. Explain what the United States Government has done for the decaying Red Indian tribes by way of allotting them locations to live in. Show children that in the northern half of the New World there are no great mountain chains running from east to west, and therefore no *barriers* to the spread of vegetable or animal life (including man).

THE VEGETABLE WORLD.

200. PLANT LIFE: DIFFERENCES IN PLANTS.

STANDARDS V. (a), VI. (a), VII. (a).

INTRODUCTORY SPECIMEN LESSON.

I. On What these Depend.—There are not so many and so great differences in plant life as in animal life; but, as before, these differences largely depend on **structure, development, food,** and **relation** to other plants.

But the **modes of obtaining** food are less differing; there is no longer question of teeth, claws, talons, etc.; it is rather one merely of **roots, stems, soils,** and **climate.**

II. Detailed Examples.—(*a*) The broadest differences in plant life depend on the following considerations:—

(1) Whether the plant is **flowering** or **non-flowering.**

(2) If flowering, whether an **exogen** or **endogen**; with one seed-

leaf, or with two; and whether supplied with fibrous or non-fibrous roots.

(*b*) The colour, scent, streaks, and nectar of the flowers, when present, differ, and on these depend their power of attraction of different insects, whose visits may carry away with them the pollen to fertilize other flowers of the same variety, or species.

(*c*) In other instances the pollen is carried by the air, as in most of our timber trees, and these attractions in the flowers are thus generally absent.

(*d*) Plants also differ widely in the means of dispersion of their seeds (*vide supra*); these being carried by the wind (on wings, or hairy crowns); by animals as food, or by their beaks and claws; and by mechanical projection from the parent plant, etc., etc.

(*e*) Plants also differ in the weight, size, form, structure, texture, surface, etc., of their leaves, according to the requirements of these. One of the most important of these requirements is, that all should get their share of sunlight, as it is in the leaf and by the aid of the sun that sap is elaborated. Each plant is in its own way well provided for this necessity; but, as a rule, upright leaves, as in grasses, are narrow; horizontal ones, wider, often divided into leaflets, as in the horse-chestnut, etc. In Australia, where the climate is hot and dry, the leaf-blades are vertical, to expose them the less to drying up by the sun. Few English trees are evergreen; the leaves, if present in winter would retain the snow which would break down the branches; in warmer countries the trees are mostly evergreen.

(*f*) The presence of hairs on plants is useful, where they are found, to protect them against excessive wet, light, and evaporation, and to keep off enemies.

(*g*) As the Life of Plants is very much modified by their food, and as the differences in this depend on the difference of soils, rather than of the atmosphere, soils become of great influence on plants. Thus, some plants flourish where there is salt in the soil, others would perish in it; some prefer granites, others chalky soils; and even varieties of the same species differ in this respect, as in the yarrows and rhododendrons, one of which prefers chalk, the other granite.

(*h*) The insectivorous plants are a striking instance of structure being modified to suit requirements in the matter of food. Thus, the sundews have sensitive hairs on the leaves, which close over insects; and a sticky secretion that glues them down, and with-

draws their juices to serve as plant-food. Others have traps to catch their animal prey.

(*i*) Plant-life is also, in many instances, dependant on the movements of parts; and for this also the structure becomes modified. Thus, the spores of many seaweeds are covered with "hairs", which are used like oars, or fins, for free movement, and for dispersion in the water. So also climbing plants rotate; many flowers shut at night; and the sensitive plant closes its leaves when touched, etc.

201. PLANT LIFE: A GENERAL SKETCH.

INTRODUCTORY SPECIMEN LESSON.

I. Range of Plant Life.—There is perhaps no part of the earth's solid surface, except rainless deserts, where some terrestrial forms of plant life are not to be met with.

And there are no oceans, seas, lakes, or rivers, without some vegetable aquatic growths in them.

(*a*) Even the coral reef just raised above the level of the sea soon becomes covered with plant life, from seeds brought by birds, ocean currents, waves, and winds.

(*b*) The same thing is seen in the volcano with its recently cooled lava streams and ashes.

(*c*) Even the seemingly bare rock faces of high mountains, nay, the very snow itself upon these mountains, and walls recently built by man, when minutely examined are seen to give a foothold to vegetation.

II. Succession.—The first forms of vegetable life that appear upon these are generally the simplest and smallest; those of which the spores can be lightly borne by the wind, such as lichens and mosses. But small as these are, they can pull to pieces the particles of the hardest rock-surfaces; and thus both feed themselves, and make the first soil and food for larger and higher growths. Neither extremes of heat nor cold altogether check this spread of vegetation in its simpler nor even in its higher forms. Provided there be only a sufficient supply of moisture, the oasis of the desert will gladden the eye with palms. Plants will flourish in hot springs and geysers, beneath the snow of Arctic regions, in cuttings just made for railway lines, and in sandy slopes just recovered from the sea.

III. Favourable Conditions.—The most favourable condi-

tions, however, for Plant Life are abundant heat, light, and moisture. Hence the densest growths are found where all three of these are met with, as in the tropics. Here the abundance, variety, size, and beauty of the plant-forms are overwhelming to the senses.

And as these draw most of their supply of food from the air, which can never be exhausted of its carbonic acid, so also in dying down they continually add to the richness of the soil, and to the supplies of plant food that can be drawn from the earth. Richly fed both from beneath and from above, the surface of the ground in the tropics is a mass of dense vegetable growths, which soon choke up paths cut by man through forests, or grow over the abandoned sites of his cities.

IV. Growth and Rest.—In temperate climates most plants have seasons of growth and cessation from this. Of the three favourable conditions the most important one, heat, is absent or reduced in winter. Hence at the approach of winter the ripened leaves fall off, and are replaced by buds, which themselves await the return of warmth before they expand into foliage. Even the stems of the annuals die down; and life is confined to the parts of the plant in the warmer soil beneath. In many instances even the roots themselves die from cold; in others, as in woody roots, the spark of life is cherished though it glimmers only, awaiting the return of spring to burst into fuller life.

This is how it is that in temperate climates most of the trees are deciduous; that is, those whose leaves fall every year: whereas in warmer climates, where there is no cold season, most of the trees are evergreen, or retain their leaves until new ones arise by their sides.

V. Elevation.—Just as plants vary in their kinds and in their modes of growth in our going from the poles to the equator, so in descending a mountain—where similar differences of heat are experienced—we likewise pass through the same differences of vegetable life. The peak of Teneriffe gives us a picture of this. At the base are dense growths of palms and such other plants as require great heat and moisture. Above this, in successive zones or belts of vegetable life, we get in vertical distribution the plants of the warm temperate, the temperate, the cold temperate, and the arctic zones, as on the surface of the earth in the horizontal distribution of plants.

VI. Unfavourable Conditions.—But we must not suppose that any region or district is unfavourable to all kinds of plant

growths. Each has its own vegetable inhabitants, which have adapted themselves to their surroundings, just as we find is the case with animals, including man. The Hindoo could not exist in the Arctic regions, nor the Eskimo in India, but each suitably maintains life in his own domain.

So where salt has been left in the soil by the ocean when the land was raised above its level, plants that require salt for their growth are met with. Where there is constant darkness, as in caves, there also are plants which cannot flourish in the light. And, similarly, whatever is unfavourable to some vegetable forms is favourable to others.

VII. Cultivation by Man.—But man within limits can alter the very nature of plants. He can gradually accustom them to even unfavourable conditions, until they will grow in places in which at first they would have perished. Almost every one of the commoner plants which are used by man for food has been thus altered by this cultivation, and altered for the better, so far as the uses to man are concerned. Thus out of one wild stock he has raised all the many varieties, so different from each other, of the cabbage tribe, as seen in savoys, cauliflowers, brocoli, etc. And these are only a type of what he has done wholesale in the cereals, and in the fruits and flowers of many other species of plants.

202. NOTES OF LESSONS—DISTRIBUTION OF PLANTS.

Matter.	Method.
I. Causes Affecting Distribution—Climate— (1) *Temperature.* (2) *Moisture in air.* (3) *Duration of sunlight.* (4) *Aspect to the sun.* (5) *Elevation*, as affecting (1). (6) *Latitude*, as affecting (1) and (3).	I. Explain the meaning of each *term*, and each phenomenon. Refer to previous lesson giving the three *conditions* of plant-growth as *heat*, *moisture*, and *sunlight*: and show that these operate on plants as a *whole*, or on great *groups* of these as well as on the life of the *individual* plant.
II. Zones of Vegetation— These are, (*a*) *Horizontal*, on the earth's *surface*, from the equator to the poles, as determined by latitude (except as interfered with by *elevation*, prevailing *winds*, ocean *currents*, and other items affecting *climate* in general). This gives us eight *zones* or belts, generally speaking about	II. Tell class that the word "*zone*" is a Greek word meaning *girdle*, and that the *Botanical Zones*, or *Zones of Vegetation*, are the girdles or belts of plants found round the *earth* and round a *mountain*. Draw a map of the northern hemisphere and put in these zones with their names. Remind the class that there will be the same in the *southern* hemisphere, but taken in a reverse order; and with allow-

NOTES OF LESSONS—DISTRIBUTION OF PLANTS—*Continued.*

Matter.	Method.
10° or 600 miles in width, in two corresponding halves, north and south of the equator, one in the northern and the other in the southern hemisphere. These zones represent ladders consisting of eight steps or rungs, the foot at the equator, the top at the pole; but ladders laid flat (horizontal) on the ground. These are:—	ances to be made for the larger proportion of *land* in the one and of *water* in the other hemisphere, since these masses of land and water largely affect *climate* and consequently *migration.*
(1) *Equatorial Zone*, of palms, bananas, and other tropical growths, with *endogens* largely predominant, and all of a very luxuriant growth owing to the great *heat* and *moisture*.	(1) Point out on the map and diagram that this is a belt of 30° or 15° each side of the equator. Explain "*endogens*" as trees without bark, rings, and pith.
(2) *Tropical*, of sugar-cane, date palm, giant tree-ferns, coffee, etc., again mostly *exogens*.	(2) As both *heat* and *moisture* are less here than in (1), the plant growth is less luxuriant, but still dense.
(3) *Sub-Tropical*, with laurels, myrtles, and other *evergreens*, and cotton as well as sugar-cane. The tropics is that region on both sides of the equator which reaches to about 23½° north and south of that great circle.	(3) Explain "*sub*" used as a prefix, as equal to "*ish*" used as a post-fix in *blackish*, etc. Refer back to lesson explaining that *evergreens* abound where there are no seasons in which growth ceases.
(4) *Warm-Temperate*, with *cereals*, vine, orange, lemon, and evergreens. These cereals include especially wheat, rice, millet, and maize, and to a less degree, barley, oats, and rye, which flourish better in (5).	(4) Point out that this zone is where the highest *civilizations* flourish; and that the *cereals* are partly accountable for this, as demanding constant but not excessive labour in their cultivation.
(5) *Cold-Temperate*, with *exogens*, mostly deciduous trees, and the cereals and fibrous plants (hemp and flax).	(5) Explain "*exogens*" as trees with separable bark, with rings and pith; which are mostly here timber trees, and about two-thirds of all the trees in the world.
(6) *Sub-Arctic*, with *coniferous* timber-trees, such as fir, pine, etc.; and little wheat, but more barley, oats, and rye, in that order as we proceed towards the pole.	(6) Point out on the map that the great land masses in this region are in the *northern* hemisphere; the southern one being more occupied with great ocean sheets.
(7) *Arctic*, with *scanty* and *small* growths of the flowerless plants, mosses, lichens, etc., and no trees; but shrubs instead, these all exogens; and with a few flowering plants in addition, but only those that can withstand a severe winter, and flower and seed in a short summer.	(7) Remind the class that the most important condition of plant-growth, *heat*, is here nearly absent, except for the brief summer, and then greatly reduced. Hence only the *lower* forms of vegetable life (the flowerless plants) much abound.
(8) *Polar*, with barren wastes almost plantless, even at the level of the sea.	(8) The reasons given in (7) apply still more severely here.

NOTES OF LESSONS—DISTRIBUTION OF PLANTS—*Continued.*

Matter.	Method.
(*b*) *Vertical Distribution.*—Here we have similar zones, at the equator, in ascending a *mountain* that reaches the limit of perpetual snow. The steps here are about 2000 feet apart, to correspond with the 600 miles in the *horizontal* intervals just mentioned. But the *complete* ladder is only found at the equator, and from the sea level to the line of perpetual snow. In proceeding towards the poles a round is taken off from the bottom of this *ladder of vegetable life* for every 10° of latitude. With these conditions the character of the *flora*, or plant life as a whole, varies within each vertical zone as before in the horizontal belts.	(*b*) Illustrate the meaning of *horizontal* and *vertical* by *upright* and *level* line drawn on the blackboard. Draw the diagram of a mountain in profile, and divide this into eight belts, and within each put its *name* as given in the preceding paragraphs. Then draw this again alongside the diagram of the *northern hemisphere*, similarly divided and named, to show the agreement between *horizontal* and *vertical* distribution of plants. Draw this mountain in *eight* stages, the bottom belt being cut off successively, to mark the change brought about in going towards the poles, until we come to the *sea-coast* in the last vegetable or Polar zone.
III. Means of Distribution— These are very varied, but are chiefly:—(*a*) *Animal*; (*b*) *Physical.* (*a*) *Animal.*—These include dispersion of *seeds* by *birds*, as undigested food; the bodily transport of hooked seeds and *fruits* on the coats of *mammals*; but most of all carriage by *man*, for acclimatizing food—dyes and plants, and textile plants for clothing, in new districts. Besides all these are plants which he transports for *building* material. (*b*) *Physical.*—These agencies are very various, and include *winds*, transporting downy seeds; *waters* of ocean currents, waves, and rivers, in carrying *winged* and *dry* fruits; and *changes of climate* modifying the character of the flora, turning plants of warm countries into citizens of colder ones, and conversely.	III. Point out to the class that there is always a *cause*, a *reason* and a *means*, for the various effects produced and the operations carried on by Nature. (*a*) Refer back to the lesson on *Dispersion of Seeds*; and point out that if the *seed* is transported that is all that is required, as the seed contains the future plant; and that as seeds are mostly *small*, they are an easy means of plant distribution. Remind the class that man's labours are mostly directed to procuring *food* and *clothing.* (*b*) Explain that there can be only two *explanations* of the great differences in plants: (1) That each kind was created *different* from others *at first.* (2) That a kind may *slowly alter* until in great length of time it becomes different from the stock from which it sprung, by reason of change of *climate*, *interference* by man, etc.
IV. Barriers— These means of migration just given are checked by:— (*a*) *Mountain Chains*; (*b*) *Rainless Deserts*; and (*c*) *Ocean Expanses*, except so far as human agency intervenes.	IV. Explain how difficult or impossible it would be for even the *seeds* of plants to pass over snow-clad peaks, and that they might perish also from the *cold*; and in deserts they would do so from the *drought.*

NOTES OF LESSONS—DISTRIBUTION OF PLANTS—*Continued.*

Matter.	Method.
(*a*) Thus the Himalayas running east and west separate the Botanical Province of India from that of Tibet; but the Rocky Mountains and Andes running north and south do not thus act as barriers to plant (or animal) migration.	(*a*) Compare this state of things with two gardens separated by a *high wall*, which, but to a less extent, would keep the larger and heavier seeds of one garden from passing over into the other.
(*b*) Again, the Sahara desert separates the luxuriant flora of North Africa from that of Central Africa (Uganda, etc.). Compare also the fruitful shore-lines in parts of Arabia with the central desert of that peninsula.	(*b*) Remind the class that *moisture* is one of the conditions of growth; and that though seeds may lie dormant for years when kept perfectly dry, they must have moisture to germinate.
(*c*) Contrast the flora of Australia with that of South Africa and South America, and do the same with the latter two in the same latitudes. But the plants of England have been acclimatized by man in the antipodes, in Australia, and New Zealand.	(*c*) Explain how easy it is for *man* to carry in a little more than a month seeds and even growing seedlings from England to Australia; and that we in return have brought Australian trees to England (Eucalyptus).

203. PLANT LIFE: THE ROOT.

INTRODUCTORY SPECIMEN LESSON.

I. What it does.—If we pluck up a growing plant from the soil, and leave it, in a short times it **fades, withers,** and **dies.** But this is not altogether from the loss of **soil**; for if we put the roots of the plant after a time, and before death, into water, it revives and lives for a certain period longer.

Water is thus taken up by the root; and this is one of the most important vital functions of the root. (*Vide* Part II.)

II. Root-Food.—But even if the roots are constantly **kept** in pure water, the plant will not continue to grow and produce fresh substance, and specially will not produce seeds. The water was necessary, not only **as** water, of which there is so much in every plant, but as a **carrier** or vehicle to take up **dissolved** matters for the feeding of the plant.

This must be so, for when we burn the **dry** plant, we find in the **ashes** many **solid** substances, and these could have entered the plant only by the root. These include flinty matter, phosphorus, potassium, sodium, and lime salts.

So the root is an **organ of nutrition**, as well as a means of mere **mechanical support**, to the plant.

In **herbaceous** plants which live two years or more, the root also serves as a **storehouse or reservoir of nourishment**, gathering up, like the bees, in one season what will be required for growth in a succeeding period. In these cases the roots, of course, are **enlarged**; and often become tuberous, as in the dahlia.

III. How obtained.—We have seen that the solids taken up from the soil must first be **dissolved** before they can become absorbed. At the ends of the roots are **rootlets**; and at the end of these again little white caps and spongy masses, made up of cells. Fluids can pass through these, and so be transmitted from cell to cell, going up the root (and later on up the stem). But as they so pass, the cells take out of these fluids the raw materials of what is required for growth, in order to convert them into gum, sugar, starch, woody tissue, etc.

The root thus **descends** out of light into **darkness**; and is at first all **cellular**, or with no woody tissue in it. Later on it often becomes more or less woody, with spongy extremities at the ends of the rootlets; but it never gives off **leafbuds** like the stem; and never has "**mouths**" (stomata) like the leaves for taking in carbonic acid from the air.

IV. Irregular Roots.—Fresh roots will grow out of stems, as we see in making and growing **cuttings** of geraniums, fuchsias, willows, etc. But in these cases, they serve just the same purposes as the original roots, or their **functions** are the same. Sometimes roots are found on stems in the **air**, as in the **ivy**, and these are used for **climbing** purposes; or they grow downwards and **into the earth**, as in the banyan tree, thus making a forest out of a single tree. Sometimes they grow on or into **other plants**, as in the parasites, such as the mistletoe on oak and apple trees.

In the lowest and flowerless forms they sometimes become white, long threads, or **strings of cells**, as in the "spawn" of mushroom, the so-called "roots" of fen, mould, etc. But they still serve the same feeding purposes as in ordinary and real roots.

204. PLANT LIFE: THE STEM.

INTRODUCTORY SPECIMEN LESSON.

I. What it does.—The **stem is** a continuation from the root in **growth**; and it also continues, in some respects, the **work**

or functions of the root. Thus, it takes up the dissolved food-stuff obtained by the latter from the soil and passes it on into the leaves. But it differs from the root in giving out leafbuds, in seeking the light, and in growing all through, and not, as in the roots, at the spongy extremities only, as a rule.

Another of its great functions is to spread out the leaves of flowers and fruits to the light and heat of the sun.

In some cases, as in the underground stem of the potato, it also serves as a storehouse, or reservoir of food for the use of the future plant.

The value of the stem for transmitting sap from the roots to the extremities, or to the leaves, may be seen in the long stems, sometimes five hundred feet in length, of the cable-like vegetable growths in the forests of tropical regions; and in the trunks of the giant Wellingtonia of California, which are sometimes five hundred and fifty feet long.

That the stem does act as a pipe or channel, to pass liquids through from the root to the leaves, is seen by putting cut stems of partly withered plants or flowers into water; when for a time they revive, and growth and development go on, even buds expanding into flowers, etc. We may also see this in elm trees which have been cut down in the preceding autumn, and which yet give out twigs with leaves on them in the following year.

II. Irregular Forms.—Whilst stems are generally erect and aerial they may be creeping and subterranean; and then, of course, their functions partly change with their changed habit and structure.

The leafbuds may also change into tendrils for climbing, as in the vine; or spines, thorns, and prickles may arise on the stems. In the mushroom, fen, mould, and other flowerless plants, the stems may consist merely of long threads of white cells, or of flattened expansions, as in sea-weeds.

III. Origin of Stem.—All the plant comes out of the seed. This when it germinates produces two shoots. Of these one (the radicle) gives the future root; the other (the plumule) gives the future stem. From the first the latter seeks the light, and puts forth one or two leafbuds, or seed-leaves, according to its kind.

205. PLANT LIFE: FUNCTIONS OF LEAVES.

INTRODUCTORY SPECIMEN LESSON.

I. The Lungs of the Plant.—One of the most important functions of the leaves to the plant itself, is that of taking in and giving out gases. The gas taken in is carbonic acid; that given out and made from the former, is oxygen. That is, the oxygen which is combined with the carbon in carbonic acid is set free by the chemistry of the leaf; and the carbon is retained in the structure of the plant, to make it grow, and add to its bulk. This work requires sunlight to enable it to be carried on: and is, therefore, most briskly performed in the day-time. It can be done under water in the case of aquatic plants, the carbonic acid of the water being broken up as before into carbon and oxygen. It is in this way that many ponds are kept purified by means of aquatic plants.

We can prove that this work is done in leaves by placing a spray of peppermint in water containing carbonic acid in solution in a glass vessel in the sunlight. The bubbles of oxygen will then be seen to form on the leaves, and to break, rise, and collect at the top of the vessel, and drive down the water in it. We can prove that the gas thus collected is oxygen, by burning a splint of wood in it, as it supports the combustion of this very readily.

II. The Skin of the Leaf.—Our skin is largely employed to give off water from the blood in the form of perspiration and sweat. The leaves do the same for a plant. This we can prove by placing succulent leaves in a closed vessel, when we find the inside of the vessel becomes beaded with drops of moisture, which can have proceeded only from the leaves. A sunflower will in this way give off as much as twenty pounds of moisture in a single day.

This is the way in which the moisture taken in at the root, and passed up the stem, finally quits the plant at the leaves as vapour, having left behind it the solids in it for making elaborated sap for plant growth. Our skin will also to a slight extent do the opposite, or give out moisture. If a man sits in a bath the water slightly passes through his skin or is absorbed by it.

In the case both of taking in and giving out of moisture, the work is mostly done on the under side of the leaf, or the side turned from the sun; and that is why the leaf does not wither or droop more in the hot sun than it does.

In both cases, also, the thinner the outer skin of the leaf, and the

less **waxy** it is, the more readily the leaf does this kind of work. So **young** leaves perform their task in this matter better than old ones. The moisture passed out, or **exhaled as vapour**, also goes through the little openings or "**mouths**" (stomata), on the surface of the leaf, and specially on the **under** side of it.

In the "**pitcher-plant**" the moisture passed off from the leaf collects in quite large quantities in the "**pitcher**" formed by the leaf, and even from the **arum** plant as much as half a pint has been collected in one night.

Plants thus exert a very important effect on the **climate** of a country. They draw up the moisture from the **soil**, and then pass it off into the **air**, thus cooling the air just as their **shade** does the **ground**. When planted as forest trees they often by these means improve a too dry climate.

III. Leaves are Secreting Organs.—In the human body are special organs used to "**secrete**" or make special fluids, such as tears, bile, etc. The leaves of **plants** act in the same way. They turn the food-stuff, or **raw** sap brought from the roots through the stem into the leaves, into the **manufactured article** or **elaborated sap**. This then descends from the leaf, and in doing so makes new wood, as well as starch, sugar, gum, resin, india-rubber, gutta-percha, poisons, etc., according to the kind of plant. If the leaves of plants be **stripped** off or become **diseased**, or if the plant be kept in **darkness**, these secretions are also either altered or checked from being made. This is the reason why we tie up lettuces and cabbages, earth up celery, shut up sea-kale and rhubarb in pits, etc.; the keeping out of the **light** stops the making of these secretions which otherwise are unpleasantly "strong" in taste, and the plants are thus "blanched" and made more eatable.

206. PLANT LIFE: FUNCTIONS OF THE FLOWER.

INTRODUCTORY SPECIMEN LESSON.

I. Functions of each Whorl.—As the flower is made up of **four whorls**, or circles of modified leaves, each of these has its own special function.

Broadly, the two **outer** whorls are:—

(1) To keep out **wind** and **wet** from the inner whorls.

(2) To **attract insects**, which shall convey the pollen in the next circle to the innermost one of that or of a kindred plant.

II. The Stamens or **Dust-Spikes.**—The function of these is to produce **pollen**; and the function of the pollen is to make the

"ovules" in the "seed-box" of the innermost circle fruitful, so that they may produce plants and continue the race.

The outer whorls are therefore "envelopes"; the two inner essential, or necessary to the very existence of the species, being found either on separate plants, or in separate flowers on the same plant, or united together in the same flower on the same plant.

III. The Seed-box or Pistil.—This is at the centre of the flower, and surrounded by the three outer circles, or by as many of these as are present.

At the top of the pistil is a knob (stigma) or swelling of various shapes according to the kind of plant. This at one season has a sticky juice on it. When the wind, or insects, bring the pollen-grains of a plant of the same kind to this knob they fall on it, and remain there held fast by this sticky juice. Then the pollen-dust begins to sprout, as a seed does: and a long thin thread of white cells grows out of the pollen-grain and penetrates into the knob at the top, and grows down the style of this, and so at last reaches the little baby seeds (ovules) in the seed-box. They join these ovules, and grow into them; and in some wonderful way turn these into fruitful seeds.

When this is done the flower has completed its work, and falls away, leaving fruit or fruit-and-seed behind it. Sometimes the whole plant also dies when this work of the flower is done, as there is nothing else left for the plant to do. This is the case with those plants that grow and flower in a single year, or the annuals, such as nasturtiums, etc.

All this means that the flower is not an organ of nutrition, as the root, stem, and leaves are; but an organ of reproduction, or a means of reproducing the future plant.

IV. Use to Man.—Besides being thus useful to themselves, and to insects in furnishing them with pollen for food, flowers are useful to man:—

(1) In producing fruit.

(2) In giving colour, to please the sight.

(3) In giving scent, to please the sense of smell.

207. PLANTS AND CARBON.

INTRODUCTORY SPECIMEN LESSON.

I. What Plants Feed on.—We have already learnt that plants have roots to fix them in the soil, and to draw up water and certain substances in solution from the soil and from the

manures we apply to it. But plants draw most of their substance not from the ground, but from the **air**; and this part of their food-stuff is **carbon**, made from the **carbonic acid** of the atmosphere.

II. Ashes and Charcoal.—If we burn in the air a log of wood, we find we have left a very small quantity of **ashes**. This part of the plant all came out of the soil. But it is a very small proportion of the whole, though it contains in a solid form most of the soluble solids drawn up through the roots.

But if we char the log in a closed vessel—not allowing the oxygen of the air to consume it in flame and gases—we have a **charcoal** cast, or mould, of the log left. This is **carbon** and represents pretty well the proportion of the plant that was made out of the carbonic acid of the air.

So this shows us that the plant principally lives on materials obtained from the air, and not from the ground.

III. How Obtained.—This carbonic acid is taken in through the mouths (stomata) on the leaves. These are too small to be seen with the naked eye; but they are as **numerous**, as small. Mostly, they have what we may call **two lips to each mouth**; and the mouth can open and close by the closing and drawing together of these "lips".

Through these mouths the carbonic acid enters as a **gas**; and the plant turns the carbon of it into a **solid** form, and lets the gaseous oxygen of it go free; thus **boarding** itself, and paying its **house-rent** out of its **lodger**.

So whilst the **animal** lives on the carbon of grass, grain, etc., and turns it into carbonic acid, the plant takes this carbonic acid, and once more turns it into carbon, in grain, grass, etc. The two operations thus go on their merry-go-round for ever. If animals ceased to exist, plants after a time would also do so, because there would not be enough carbonic acid made for them to live on; and we know what very soon happens when grazing animals are left without vegetable food,—they also cease to exist.

IV. Illustrations.—If we wrap flannel round a bottle full of water, and allow the water to overflow so as always to keep the flannel wet; or, if we simply put the flannel into a saucer of water, the mustard seeds will grow on the flannel with nothing else but water for the roots, and the carbonic acid of the air for the leaves, to feed on. This shows the **sufficiency** of air (and water) for early plant life. But if we shut plants up and keep out the air from them they will cease to grow, showing the **necessity** for the air.

Again, if we suspend seeds in the air without soil, and give them

a little water when sprouting, and add as they grow a little manure in solution, they will continue to grow as well without soil as with it, provided there is always sunlight to enable the plant to digest its carbonic acid, and turn it into carbon and oxygen.

This sunlight is just as necessary as the water and the carbon. So there is always a struggle going on among plants to get this sunlight—trees killing the shrubs beneath them, that die for want of it; shrubs doing the same to grasses; and even trees giving out branches only on the side turned to the light, and growing up without branching when crowded close together in forests. This is the reason why forests do not grow where grass does, and why grass does not grow where forests do. And this is the reason too, why leaf-blades are turned flat to the sunlight to catch it, and why they are so shaped as to get the most of it, and yet to leave the most possible for their neighbours.

208. DISPERSION OF SEEDS AND FRUITS.

INTRODUCTORY SPECIMEN LESSON.

I. Why Necessary.—(*a*) Soil-exhaustion. If the same species of plants constantly grew on the same spot, they would exhaust the soil of the special substances which those plants take for their materials of growth. The farmer knows this, so he avoids the difficulty by a rotation of crops, not growing in succession the same crops on the same ground, but varying these. This gives the land a rest, and also time to get out of the air, manures, etc., a good supply of those particular substances of which the plants had formerly deprived it.

The same thing is done naturally by the plant itself disseminating or scattering to a distance from the parental home its seeds, or the fruits containing these.

(*b*) Elbow-room. There would not else be enough room for both parents and offspring on the same spot, any more than there is for animals and man. Each must seek its own living on its own account, or a vacant spot where there is room for it.

II. Means of Dissemination.—(*a*) By the aid of animals. Plants are rooted to the site of their growth; but most animals are locomotive. The latter are therefore used in Nature to transport the former.

As instances, we have burrs with curved hooks to fasten on the wool of sheep and hair of cattle, by which means the seeds are

carried from one hedge-side or bush to another, where the animal gets rid of them by rubbing them off. Other instances are the berries and stone-fruits which are eaten by birds, and the seeds of which pass through them, and are dropped on the soil still alive and undigested, as in the raspberry, blackberry, cherry, peach, apricot, etc. Many of these berries remain on the tree for a long time, as the haws, rose-hips, holly-berries, etc., waiting, as it were, for their living transport to carry them away.

In the case of the mistletoe, the thrush carries away the fruits, and seeds in them, by means of the sticky "bird-lime" which clings to their feet; and these seeds are cleaned off on apple, oak, and other trees to grow there in their turn.

(*b*) By means of wind. (1) Among the commonest instances of wind-power as a means of transport of seeds we have the winged seeds, as in the feathery, downy hairs of thistle-down, dandelion, lettuce, groundsel, and many others of the composite order. These travel so far and so fast—being so light and airy—that after forest-fires they often cover the ground with a new growth within a year. In this way also the coltsfoot greens over a new railway embankment or cutting long before grass can do so.

(2) Among the winged seeds we may also include the fruits of the sycamore, etc., known as "keys", because of the projecting wings, like those on a key of a particular shape. On these the wind acts as on the feathers of an arrow, or on the thicker extremity of a weathercock.

(3) Other seeds are contained in capsules, as in the poppy. As the plant is violently swayed by the wind, the small seeds are shed out of the pores at the top of the capsule and blown to great distances by the wind.

(4) In other cases the capsules burst or explode, and shoot out their contents like the bombshells of artillery, as in the balsam, and the squirting cucumber, so-called because of this action.

The remaining section of the "Teacher's Manual of Lessons in Elementary Science" is devoted to a few types in,

"(*b*) *The commonest elements and their compounds. Standard VI.*"
—Revised Code.—Schedule II.

"(*b*) *Properties of common gases. Standard VII.*"—Schedule II.

"*Simple chemical laws in their application to common life and industries. Standard V.*"
—Supplement V.—Schedule II. Course J.

209. CHEMISTRY: MATTER IS INDESTRUCTIBLE.

INTRODUCTORY SPECIMEN LESSON.

I. Burning Candle.—In learning that a candle as it burns gives off carbonic acid and water, we also learn that the matter of which the candle was made is not altogether destroyed and put out of existence, but that it is merely changed, or turned from one form of matter into another.

But this might have been true of one part of the candle only, and not of the whole. We did not then weigh our carbonic acid and water to see whether we got full change for our shilling.

II. An Experiment.—We will now, therefore, burn our candle in a glass globe, into which clear lime-water has been first poured. This lime-water will collect, and hold in solution, the carbonic acid given off from the burning candle.

But in this experiment we cannot weigh the carbonic acid and water produced. So we will alter our experiment in order to do so.

Here is a piece of candle in a glass tube at this end of a balance. Over the flame of the candle is another tube with soda in it, which collects the carbonic acid and water made by the candle burning. As these are being collected the increase of weight makes that end of the balance go down as the candle disappears, showing that there is more matter there, not less than before. The increase is due to the oxygen of the air taken in to make carbonic acid; the carbon being furnished by the fat of the candle.

We can weigh this oxygen supplied from the air; and then we find that the increase of weight at the one end of the balance is exactly equal to this weight of oxygen.

So the matter of our candle has not been destroyed in burning, but only changed into another form of matter.

III. Other Experiments.—(*a*) The same thing is shown in burning a piece of magnesium wire. This takes the place of the candle in the former experiment.

In burning this also uses up some of the oxygen of the air; but it does not make carbonic acid and water in doing so, for magnesium has no carbon in it to make carbonic acid, and no hydrogen in it to make water. It leaves in burning a white powder instead, which is magnesium and oxygen combined, or united together, as oxide of magnesium.

So here again there is no destruction, but only a change of matter.

(*b*) The same thing may be shown by burning phosphorus instead of magnesium. Here, also, the oxygen of the air unites with the phosphorus, but white fumes are given off instead of a white powder. These fumes, if weighed after settling down, will give exactly the weight of the phosphorus burnt and the oxygen combined with it in doing so. The matter of the phosphorus has therefore not been destroyed, but only changed.

(*c*) Exploding gunpowder would teach us the same lesson.

And as no one has ever been able to get less weight out of any chemical substances after they have been experimented on than before the experiment was performed, we say all matter is indestructible.

210. THE CHEMISTRY OF WATER.

INTRODUCTORY SPECIMEN LESSON.

I. Matter.—All matter is divided by the chemist into two kinds:—

(1) Those things out of which he can get nothing else, which are all one and the same thing, which he calls simple substances or elements, as gold and all other metals; and,

(2) Those out of which he can get something else, and which are made up of two or more things or substances, or compounds, as in candles, carbonic acid, etc. We have now to see to which of these water belongs.

II. An Experiment.—Into this basinful of water we will put a very small piece of the metal potassium. This sets the water on fire, for it lays hold of something in the water, which we shall find out to be oxygen, just as the magnesium wire united with the oxygen of the air. It also sets on fire something else that is also in the water, and which we shall find out to be hydrogen; and it is the burning hydrogen gas that gives us the flame we see. So the potassium has shown us that water is made up of two gases, oxygen and hydrogen, and, therefore, that it is a compound body.

In the case of the burning magnesium wire, we had left a white powder. Here, as with the potassium united with the oxygen of the water, we have a white powder. But this dissolves in the rest of the water, though we could get it back again in the solid form, as we did our salt and sugar in a former lesson (*vide* Part III.). Then, of course, we could weigh it.

We could also weigh the hydrogen given off from the water by the potassium instead of burning it. This could very easily be done by plunging the potassium below the surface of the water, and holding over it a glass tube to catch the hydrogen as it escaped and rose owing to its lightness.

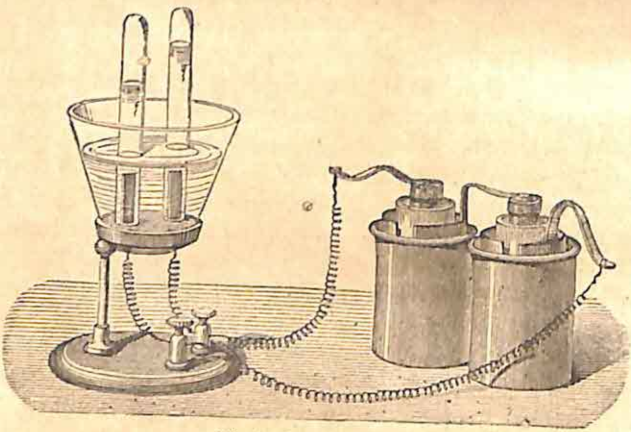
This experiment would also enable us to question our prisoner, and find out what its character is.

We will now do this, and then place a light to the mouth of the tube containing it, and we see that the gas burns with a yellow flame. We have therefore learnt,

(1) That water is made up of two gases, oxygen and hydrogen.
(2) That hydrogen is light and inflammable.
(3) That it burns with a yellow flame.
(4) That oxygen helps combustion, or "supports combustion".

III. The Electric Battery.—But we could also have split up our water into its two gases by means of electricity.

By passing an electric current through two tubes filled with water, in which the poles of the battery terminate, we get bubbles



Electrolysis of Water.

of gas given off in each tube, and one of these is proved to be oxygen, because it supports combustion, as we see, by burning in it sulphur, phosphorus, magnesium wire, or a charred lucifer match; and the other is hydrogen, for it burns with a yellow flame.

But this experiment tells us something more than the other did. As the tube with the hydrogen in it has twice as much gas as the one with the oxygen in it, we have not only learnt what the com-

pound water is made up of, but the proportions of the ingredients in our pudding. The water consists of one lot of oxygen to two lots of hydrogen.

Now if we let O stand for oxygen, and H for hydrogen, we can make our first chemical formula--or short way of expressing what a compound consists of :—

Thus, Water $= H_2 + O$, or H_2O.

IV. Another Proof.—There are two ways of running round a circle, and though this is done in opposite directions, yet we get to the same starting point in the end.

So also we can prove that water is H_2O by the very opposite kind of experiment to that just performed.

This time we will not pull water to pieces, like a baby does a doll, to see what it is made of ; but we will make a doll out of our rags. I mean, we will take our two lots of hydrogen and one lot of oxygen, and see if we can make water with them.

First, we put these two gases in this proportion in a strong bottle. Next, we wrap this bottle round with a cloth for fear of an explosion bursting the bottle and injuring us. Now we will send an electric spark through the mixture, and there is a loud report. The oxygen and hydrogen have rushed into each other's arms, and burst into tears. I mean, that they have combined together and made water ; or H has united with O and made H_2O ; or, lastly, $H_2+O=H_2O$; which is as nearly accurate in statement as you can at present understand. (*Vide supra.*)

V. Burning Hydrogen.—But we could have proved the same thing in a less dangerous way. Let us take a jet of hydrogen, and set it alight either in the air or in oxygen. Then the hydrogen as it burns, that is, as it unites with the oxygen, makes water ; which is plainly seen in this vessel or tube in which it is now burning.

But we can even prove that water is made out of hydrogen and oxygen in a still simpler manner than this, viz., by the burning candle itself. You remember that this in burning gave off water. Or, we could even use the lighted coal gas coming out of the gas-pipe for the same purpose. Let us hold a slate, or a cold tumbler over this, and we shall soon see that the flame, in burning, makes water ; or, that the hydrogen in the coal gas unites or combines with the oxygen of the air, to make H_2O.

211. NOTES OF LESSONS—CHEMICAL ACTION.

Apparatus.—Copper turnings, nitric acid, barium chloride, sulphuric acid, mercuric chloride, potassic iodide, matches, candle, iron wire, magnesium wire, tartaric acid, bicarbonate of soda, water, test tube and rack.

Matter.	Method.
I. By Contact— Some substances when they *touch* each other change in *colour*, character, or *composition*. Thus a white, colourless liquid, with a bright red metal, may give a green liquid, and a brown gas. In this case there is great change in both the colour and the nature of the substances acted on.	I. *Pour a little nitric acid on copper turnings* in a test tube. Ask for description of substances used, viz., bright red metal (solid), and colourless liquid (like water). Note the result, a blue liquid and brown gas. ?Are the substances in the tube the same now as before? (No). What has happened to the substances? (They have changed). When did they change? (Directly they touched each other).
II. By Heat— Some substances are changed into others by the application of *heat*. (*a*) Some are *consumed* in the form of *gases* or make such. Such is the case with all *inflammable* substances, whether *gaseous* as hydrogen, converted into water; or ordinary *solid* inflammable substances, as brimstone, phosphorus, etc. (*b*) Others pass out of sight, sometimes leaving only an *ash* or powder behind. (*c*) Some do not change at all; or so *slightly* as not to be seen doing so, cooling down into their original substances and condition, or only partially altering. (*d*) Others turn from a solid to a powdery form. Sometimes this change is *physical* merely, as in baking clay, water being driven off. At others it is *chemical*, a new compound being the result, as oxide of magnesium from burning magnesium wire.	II. (*a*) *Burn a match.* Ask the class what has taken place. The match was a piece of white wood tipped with a red substance. What has it now become? (Charcoal, ash, and smoke.) The match then has been changed by heat. (*b*) *Burn a candle.* Proceed as in case (*a*). Here there is no ash and no charcoal left. (*c*) *Heat a piece of iron wire.* The wire glows, but no great lasting change takes place, though the colour alters slightly, and really an oxidation takes place. (*d*) *Heat a piece of magnesium wire.* Proceed as in (*a*) and (*b*), contrasting with result of (*c*). Here the magnesium is converted into a white powder, from the combination of magnesium and oxygen derived from the air.
III. By Solution— Here we deal with liquid substances, or solids which become so in liquids. In the change from a	III. (*a*) *To a mixture of tartaric acid and sodium bicarbonate add water.* Ask what takes place.

NOTES OF LESSONS—CHEMICAL ACTION—*Continued.*

Matter.	Method.
solid to a liquid condition we frequently get chemical changes, in both the solid and the liquid, or in the former only.	(1) The water *dissolves* the white powders.
(*a*) When salt or sugar is added to water we get merely a *solution* of each. But,	(2) Bubbles are formed. (3) These bubbles consist of *gas*. (4) This gas is carbonic acid.
(*b*) In mixing tartaric acid and bicarbonate of soda together with water we get a gas (carbonic acid) given off.	(5) One of the substances was an *acid* (tartaric acid), the other was an *alkali* (carbonate of soda): the two have acted on each other, and there is a third substance produced, a *salt* (dissolved in the water).

212. NOTES OF LESSONS—CHARCOAL: CARBON.

Matter.	Method.
I. Introduction— In olden time "*coal*" was the name of *any fuel*, such as straw, wood, etc., just as "*meat*" stood for any kind of *food*. So a burning piece of wood was "*coal*", and a burnt piece was *charred-coal*, or wood turned black from burning. Now we char *coal* on purpose to get *charcoal* in the form of coke, for various uses; and we bake wood for the same purpose.	I. Show class some wood, and some bone or "animal" charcoal, a charred stick; peas, wheat, barley, etc., parched to blackness; some coal, coke, and paper-ash. Let class note the *black* colour of all these substances; and that they have all been changed by slow and *imperfect combustion*.
II. Properties— (*a*) Charcoal is black, or bluish-black.	II. (*a*) Verify this in the several specimens.
(*b*) We can see that it retains the *structure* (texture), grain, etc., of the wood from which it was made.	(*b*) Show this in a piece of animal charcoal (bone); and in a charred stick.
(*c*) But it is much *lighter* than *wood*. It is wood with much of the watery and gaseous substances of wood burnt out of it: it is the same with *coke* compared with coal.	(*c*) Show the class that the charred wood is nearly of the same *bulk* as at first; yet something (gases, etc.), has been burnt out of it.
(*d*) It will not burn with *a flame* as the wood did. The *inflammable* part, or the part which makes flame, has been already consumed in the slow burning or the charring.	(*d*) Try to make the charred stick *blaze*: blow on it, and it only glows to a white heat. The gases that make flame have already done so, or have passed off as gases.
III. How Made— *Charcoal* is made in or near a *forest* of oak, birch, pine, or other	III. Remind the class that here *combustion* can only be carried on with oxygen.

NOTES OF LESSONS—CHARCOAL: CARBON—*Continued.*

Matter.	Method.
trees. The trunks and branches are cut on the spot into lengths, and piled around stakes driven in the ground, so as to build up a flattened cone-shaped structure. The looser branches and loose timber-growth are placed around these logs, and all is *covered* with turf and earth, except over the central stakes. The outside covering is to partially exclude the air. If the air could *freely* get at the logs as in a bonfire they would not "*char*", but be consumed. If *no* air got to them they would *smoulder* feebly, and the fire would go out. The fire or kindling is added at the centre.	If the air be partly shut out from the lighted heap, the combustion will only be *partial*. This is what is wanted. If there were plenty of *oxygen* this would unite with all the carbon of the wood and make *carbonic acid*, which would escape as gas and leave no *carbon* behind. Remind the class that most flames contain carbon in them; and show that there is only imperfect combustion in them. Thus the soot from a fire, and from a burning lamp, consists of carbon. Tell class that if we limit the supply of air to an oil lamp we make the lamp "smoke", (show this before the class); and that if we do this still more we can make "lampblack", a very good form of carbon.
IV. Animal Charcoal— Animal charcoal is made by heating *bones* instead of wood. Another form of it is lampblack, used in making printers' ink, etc., from oily and fatty and resinous substances.	IV. Show class a piece of animal charcoal, and also some lampblack, made out of fat combusted with a small quantity only of oxygen.

213. SULPHUR.

INTRODUCTORY SPECIMEN LESSON.

I. What it is.—This is one of the **simple bodies, or elements**, and it is found as such, or in a **pure or free** state, near volcanoes, such as Mount Etna in Sicily It is also found mixed, or adulterated with earthy matters, and other impurities, which have to be got rid of.

II. Properties.—(*a*) Sulphur is **inflammable**, that is, it will burn in the presence of oxygen, as magnesium wire does. In doing so it gives off a **blue flame** and **suffocating fumes** of sulphurous acid, just as carbon burns in the air, or in oxygen, and gives off carbonic acid.

(*b*) **Sulphur Compounds.** But, unlike carbon, sulphur will also combine with **metals**, as well as with oxygen. This is how it is that nearly all our metal ores contain sulphur in them; and that

in roasting and smelting them, the first and most necessary thing to do is to get rid of this sulphur.

(*c*) **Sulphur also gives us sulphuric acid.** This **sulphuric acid** is the most important chemical we have for commercial purposes, as with it we make **soda**, etc., and from soda, **soap**, etc.

To make this sulphuric acid, sulphur or some ore containing it, is first burnt in air in large leaden chambers to form **sulphurous acid.**

With steam and other things, in a way too difficult to explain at this stage, this sulphuric acid, or **oil of vitriol**, is made chiefly around Manchester and Newcastle-on-Tyne to the extent of many thousands of tons weekly. With this nearly all other acids can be made, such as hydrochloric acid, or **spirits of salt**, made from sulphuric acid and common salt. And from the hydrochloric acid again, we can make **chlorine**, and this is one of the most powerful **bleachers** used in bleaching calico, lace, etc.

(*d*) This means, therefore, that sulphur is of use in the **bleaching trades** because of its employment to make chlorine. But sulphur will also itself bleach; or rather it does so in combining with the oxygen of the air to make sulphurous acid. The fumes of the latter act as a bleacher, as we can prove by bleaching a bit of coloured straw, by placing it in a closed cigar box in which sulphur is made to burn and give off fumes of this sulphurous acid.

THE END.

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